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AIRCREW TRAINING DEVICES: UTILIZATION.(U)

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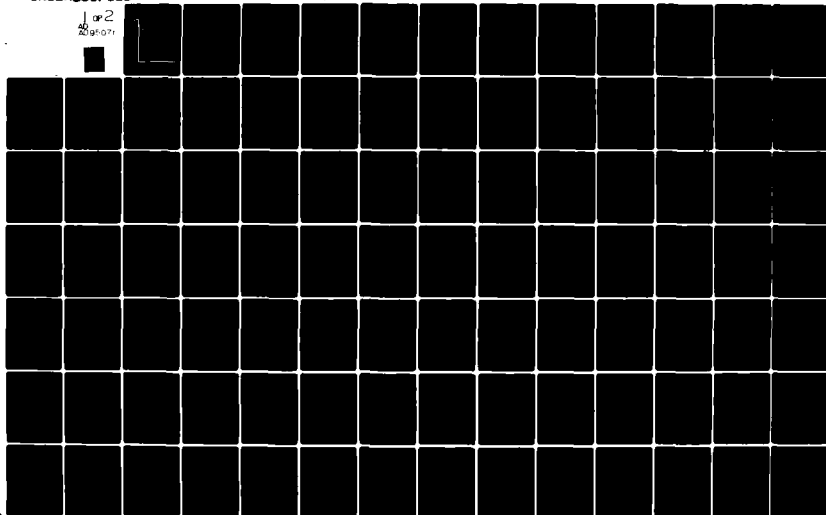
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AIR FORCE



HUMAN RESOURCES

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**AIRCREW TRAINING DEVICES
UTILIZATION**

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Logistics Research Branch
Wright-Patterson Air Force Base, Ohio 45433

January 1981

Final Report

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LABORATORY

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

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This final report was submitted by Seville Research Corporation, 400 Plaza Building, Pensacola, Florida 32505, under Contract F33615-77-C-0067, Project 1710, with the Logistics and Technical Training Division, Air Force Human Resources Laboratory (AFSC), Wright-Patterson Air Force Base, Ohio 45433. Mr. Bertram W. Cream was the Contract Monitor for the Laboratory.

This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

ROSS L. MORGAN, Technical Director
Logistics and Technical Training Division

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Commander

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<p>This report, prepared for personnel responsible for effective and efficient use of aircrew training devices (ATDs), identifies factors which influence ATD utilization and provides guidance concerning ATD use. Information upon which the report is based was obtained from reviews of the professional/technical literature, observations of ATD management and utilization practices, interviews with personnel involved in those practices, and visits to manufacturers and R & D agencies. Principal topics of the report are (a) complexity of aircrew skills learning and adaptation of ATD usage to requirements for effective and efficient training; (b) structure of ATD training in relation to the skills being trained and ATD capabilities; (c) instructor selection and training.</p>			

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management of ATD instructors in ways consistent with effective instruction; (d) development and maintenance of attitudes among instructors and students conducive to a favorable training environment; (e) assessment of ATD training effectiveness and use of assessment data to improve ATD training; and (f) maintenance of training quality after ATD programs become operational. This report is one of seven prepared under the Simulator Training Requirements and Effectiveness Study (STRES).

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PREFACE

This report describes a portion of a study of training through simulation in the U.S. Air Force. It is one of seven technical reports prepared for the Air Force Human Resources Laboratory, Logistics and Technical Training Division, under Contract F33615-77-C-0067, Simulator Training Requirements and Effectiveness Study (STRES). The remaining six reports are identified in Chapter II of this document. The reports cover work performed from August 1977 through January 1980.

The work was performed by a team made up of Canyon Research Group, Inc; Seville Research Corporation; and United Airlines Flight Training Center. Canyon Research Group, Inc. was the prime contractor; Mr. Clarence A. Semple served as the Program Manager. The Seville Research Corporation effort was headed by Dr. Paul W. Caro. The United Airlines effort was headed initially by Mr. Dale L. Seay and subsequently by Mr. Kenneth E. Allbee.

Mr. Bertram W. Cream was the AFHRL/LR Program Manager. Other key members of the AFHRL/LR technical team included Dr. Gary Klein and Dr. Thomas Eggemeier. A tri-service STRES Advisory Team participated in guiding and monitoring the work performed during this contract to assure its operational relevance and utility. Organizations participating in the Advisory Team were:

- Headquarters, USAF
- Headquarters, Air Training Command
- Headquarters, Military Airlift Command
- Headquarters, Aerospace Defense Command
- Headquarters, Tactical Air Command
- Headquarters, Air Force Systems Command
- Headquarters, Strategic Air Command
- Tactical Air Warfare Center
- Air Force Manpower and Personnel Center
- Air Force Test and Evaluation Center
- USAF Aeronautical Systems Division
- Air Force Human Resources Laboratory
- Air Force Office of Scientific Research
- Army Research Institute for the Behavioral and Social Sciences
- United States Navy Training Analysis and Evaluation Group

The authors wish to express their gratitude to the hundred of people in the United States Air Force, Navy, Army, Coast Guard, NASA, FAA and industry who contributed to this program by participating in interviews and technical discussions during program data collection.

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CHAPTER I

INTRODUCTION AND SUMMARY

The U.S. military services have been users of flight training devices and simulators for over half a century. These training media, known collectively as aircrew training devices (ATDs), include cockpit familiarization and procedures trainers, part-task trainers, mission trainers, operational flight trainers, and weapons systems trainers. In recent years, use of ATDs has increased to the point that the devices represent major aircrew training resources, and their effective and efficient design and use are matters of continuing concern.

In response to this concern, the U.S. Air Force has undertaken a programmatic study of factors involved in their design and use. This project is titled Simulator Training Requirements and Effectiveness Study (STRES). The general objectives of STRES are to define, describe, collect, analyze, and document information bearing on the cost and training effectiveness of flight simulators. Topic areas covered in the project are: fidelity; instructional support features; simulator utilization; life cycle costs; and worth of ownership. Products of the project are intended for those who manage and use simulators for training, evaluate simulator requirements, and design, procure, and maintain these devices. Chapter II describes the STRES project in more detail, as well as the approach followed in its execution.

This volume is one of seven prepared during STRES. It addresses concerns related to the utilization of ATDs. Other volumes prepared during the project are identified in the description contained in Chapter II.

PURPOSES OF THIS REPORT

The purposes of this report are to identify factors which influence the utilization of ATDs and to provide guidance concerning ways of enhancing the effectiveness and efficiency of the use of these devices. The contents of this report are based upon a review of relevant scientific and technical literature, observation of current ATD utilization practices, and interviews with personnel engaged in the conduct and management of ATD training activities. The scope of these efforts was determined by the Statement of Work under which the project was conducted.

This report was prepared for personnel who are responsible for the use of ATDs. These personnel include training program developers who may or may not be trained in Instructional System Development (ISD) methods, rated and nonrated ATD instructors, flight and ATD training supervisors, unit management personnel, and personnel responsible for

assessing and controlling the quality of ATD training. Others for whom this report was prepared include personnel in higher management positions who are concerned with the effectiveness of ATD training and the manner in which the resources they manage are utilized.

Based upon the requirements of the Statement of Work and information collected during this project, perceptions were developed of the informational needs of the intended audience of this report. These needs are for a working knowledge of principles of instructional technology relevant to effective and efficient ATD utilization, and guidance on when and how to use ATDs of various configurations and complexities. In addition, information is needed by these personnel regarding the management and training of ATD instructors and the influencing of their attitudes toward training and simulation. A need also was found for guidance concerning the assessment of the effectiveness of ATD training and the maintenance of ATD training effectiveness once it has been established.

REPORT OVERVIEW

Strengths and weaknesses of ATD training programs observed during this project can be related to how six questions were being approached and related problems resolved. First, was the complexity of skill learning recognized, and did the training program adapt ATD usage to the basic requirements for effective and efficient skill training? Second, was the structure of ATD training appropriate for the skills being trained and the capabilities of available devices? Third, were the overall responsibilities of instructors consonant with requisites for effective instruction, and were they adequately prepared to teach and exploit ATD capabilities? Fourth, had steps been taken to ensure the development and maintenance of attitudes among ATD personnel and students that are necessary for a favorable training environment. Fifth, had effectiveness and efficiency of ATD training been assessed and had the findings been disseminated and used to improve ATD training? And sixth, had steps been taken to ensure maintenance of training quality after an ATD program became operational?

Complexity of Skill Learning

By and large, inflight training models governed ATD training. Students simply practiced skills in devices with feedback and guidance provided according to instructors' intuitive analyses of their needs. Some of the advanced ATD capabilities and instructional support features were used; but just as commonly, others were not used at all, either because they were perceived to reduce realism or because the instructor had not learned how to use them.

Within this context, little attention was given by ATD instructors to particular cue and response discriminations that underlie skill

performance, although the status of these discriminations at a given point in training should be the basis for deciding whether to provide feedback and guidance, and in what form. Many instructors could adapt use of these factors to students' needs, but more often feedback and guidance were used according to a routine plan that did not consider students' actual needs on a moment-to-moment basis. Many ATDs are specifically designed to optimize use of these factors; if the contingencies for using feedback and guidance are not recognized, however, it is not possible to exploit them.

The most serious problem found in ATD training was the failure of most instructors to recognize the fundamental role of mediational processes in all skill learning. Mediation refers to everything a person does between receiving a stimulus and responding to it--deriving cue information from the stimulus, interpreting and processing the information, selecting a response, monitoring the response, etc. Both cognitive and motor mediations are involved.

It is because of mediation that complex learning is possible. Transfer of ATD training to aircraft performance depends entirely on appropriate forms of this process. Rather than deliberately emphasizing mediational development and use, however, ATD training was found to focus almost entirely on the overt actions of students. The crucial mediational skills were left to develop largely on their own.

Chapters III and IV are devoted to examining the complexities of learning and explaining their implications for ATD training.

Structure of ATD Training

There are many ways to structure specific aspects of ATD training to provide effective and efficient instruction. Nevertheless, certain general requirements must be met regardless of the structure used. First, training allocated to ATDs must be consistent with their capabilities. However, depending on the students' capacities to substitute mediation for physical realism, and the extent to which instruction exploits these abilities, a variety of tasks can be trained in ATDs with ostensibly limited features.

Second, tasks must be separated, and grouped, in ways that promote effective and efficient learning. Depending on the task and discriminative abilities of the student, particular training sessions may need to focus on part tasks or grouped tasks. There are ways to decide which approach is needed, and they are based on the processes of skill acquisition. Similarly, there are ways to promote the functional integration and coordination of skills, whether learned separately or together.

Third, the duration and frequency of practice should be such that progress is made during skill acquisition and the skills learned are

retained. Factors to be considered include the need to reduce interference on some occasions, and to promote the accommodation of interference on others; the amount of forgetting that occurs between practice sessions and over time after skills are learned; and the level of mastery previously achieved by students. The nature of individual tasks practiced in sequence is also an important factor in determining duration of single ATD sessions, especially for less experienced students.

Fourth, the effectiveness of ATD training in some skills can be affected by when it occurs relative to academic training and aircraft experience. For some tasks, later ATD practice can provide concrete meanings for cues and actions learned abstractly in academic training; in other cases, academic training may be almost meaningless unless students have already had certain ATD (or aircraft) experiences. Similarly, experiences in aircraft may need to precede ATD training for some tasks and follow it for others.

Chapter V examines bases for structuring ATD training programs with respect to these four considerations.

ATD Instructors

As a rule, the more effective ATD training programs observed during site visits were those in which instructors had been trained to teach and were taught specifically how to use the ATD and its instructional support features. These programs also minimized non-instructional duties that would interfere with teaching performance. In most effective programs, ATD instructors were considered an elite group by their peers and students. To the extent the reverse of these conditions was true, training programs appeared to have been negatively affected.

Chapter VI discusses the effects of the selection, training, and management of instructional personnel on the quality of ATD training.

Attitudes Toward ATD Training

Attitudes of instructors toward ATD training can be of critical importance for the success of an ATD program. Not only do instructor beliefs regarding device training determine how devices are employed, but they affect the attitudes of students toward the value of ATD practice. The problem of attitudes goes beyond the instructors and students, however. Just as students "model" instructors' opinions, so instructors reflect the beliefs of their peers and supervisors. The problem of fostering favorable attitudes toward ATD instruction must be faced at the organizational level.

Chapter VII discusses causes for the conditions leading to favorable and unfavorable attitudes toward ATD training. These causes and conditions relate to how design requirements for ATDs are

determined, the manner of introduction of an ATD to a training unit, and how ATD training is conducted and managed. The need for an atmosphere of professionalism of instructors qua instructors is also explained.

Assessment of Training Effectiveness

Formal assessments of the training effectiveness of operational ATD training programs are practically non-existent. Therefore, there are no hard data to identify shortcomings of programs, or to convince doubting instructors of the value of ATD training. In fact, if one had to rely on existing documentation of training effectiveness, he could not even establish that ATD programs are worth the effort.

Formal assessment of these programs requires sophistication in evaluation methodology. No attempt is made to teach this knowledge. However, Chapter VIII is devoted to explaining what is involved to provide guidance to personnel who must judge the adequacy of evaluation studies.

Maintaining ATD Training Effectiveness

Given an effective ATD program, its quality can be maintained only if it adjusted quickly to modifications in training requirements and in design of target aircraft. Good training practices must be maintained and not allowed to evolve in undesirable directions as training personnel are replaced or student quality changes. Attitudes toward ATD training may also change for the worse over time, and management may increasingly neglect the program as its novelty wears off.

Problems such as modifications in training requirements and aircraft should be resolved posthaste. Others, especially those leading to a gradual deterioration, may not be noticeable until serious damage has occurred unless quality is monitored and corrective action taken on a regular basis. Chapter IX discusses these problems.

CHAPTER II

THE STRES PROGRAM

Aircrew training is an expensive and time consuming endeavor. At one time or another, virtually every known training method and medium has been used to develop operationally ready aircrews and to maintain their skill levels. To meet these training needs in a cost effective manner, the U.S. military has shown increased interest in the use of simulators and other ATDs. Recent requirements to economize on aircraft fuel used for training have provided strong impetus for this interest, but other factors have contributed as well. These other factors include increasingly congested airspace, safety during training, cost of operational equipment used for training, and a desire to capitalize on training opportunities that simulators provide for skills that cannot be trained effectively, safely, or economically in the air.

Because of the advantages simulation can offer over other aircrew training media, it is current Air Force policy that ATDs will be used to the fullest extent to improve readiness, operational capability, and training efficiency. Implementation of this policy requires specific technical guidance. Information upon which to base that guidance is sparse, however, and the information that does exist is not always available to those who need it. The Simulator Training Requirements and Effectiveness Study (STRES) was conceived as a means of identifying and making available the existing information related to simulator training in furtherance of relevant Air Force policies. The base of information thus assembled would provide guidance for the enhancement of present training, as well as for the focus of research and development needed to enhance future simulation-based training.

STRUCTURE OF THE STRES PROGRAM

The primary objectives of STRES, as described in the contract Statement of Work for the present efforts, are to define, describe, collect, analyze and document information bearing on four key areas. These areas are:

- Criteria for matching training requirements with simulator fidelity features;
- Principles of effective and efficient utilization of simulators to accomplish specific training requirements;
- Criteria for matching simulator instructional features with specific training requirements; and
- Models of factors influencing the cost and the worth of ownership of simulation devices.

The Air Force plan for accomplishing these objectives involves a four-phase effort. Phase I, which was concluded prior to the initiation of the present study, was an Air Force planning activity that structured the total effort so that operationally meaningful simulator training issues would be addressed on a priority basis. Phase II, the effort described in the series of reports identified below of which the present report is a part, was a 29 month study that involved collecting, integrating, and presenting currently available scientific, technical, and operational information applicable to specific aircrew training issues. Phase II also involved the identification of research and development efforts needed to enhance future simulator training. Phase II was conducted by a team composed of Canyon Research Group, Inc., Seville Research Corporation, and United Airlines Flight Training Center. Phase III is planned to be a research activity that will provide additional information on important simulation and simulator training related questions that cannot be answered with assurance with the currently available data. Finally, building on Phases II and III, Phase IV will be an Air Force effort to integrate findings, publish relevant information, and provide for updating of the knowledge base as new information becomes available.

A tri-service STRES Advisory Team was formed to help guide STRES. The team has participated in two ways. One was to assist in the Phase I program planning. The second has been to provide guidance and evaluative feedback during Phase II to ensure that products of the phase would be operationally relevant and useful. Both operational users of ATDs and the research community were represented on the Advisory Team.

A principal task of the Advisory Team was to participate in the development of objectives and guidelines for the conduct of the Phase II technical effort. As a focus for those efforts, a set of "high value" operational tasks was identified. The tasks selected were those for which potential ATD training benefits were judged to be greatest, and for which information on ATD design, retrofit, use, and worth was believed to be incomplete or lacking. These tasks also provided a focus for identification of questions and issues reflecting the informational needs of operational personnel that were to be addressed during Phase II efforts. The high value tasks identified by the Advisory Team are:

- Individual and formation takeoff and landing;
- Close formation flight and trail formation, both close and extended;
- Aerobatics;
- Spin, stall, and unusual attitude recognition, prevention, and recovery;
- Low level terrain following;
- Air refueling;

- Air-to-air combat, both guns and missiles;
- Air-to-ground weapons delivery.

SOURCES OF INFORMATION

Information from two kinds of sources was collected during Phase II to address the objectives of STRES. One kind of source was the professional and technical literature. This literature included books, conference proceedings, professional journals, research reports, military manuals and regulations, and policy statements. The second kind of source was the military and civilian personnel whose experiences related to the objectives of the study. Information was obtained from these personnel during visits to the organizations to which they were assigned.

Literature Review

Computer searches were made at the outset to identify literature relevant to all facets of the Phase II effort. In addition, each STRES team member was responsible for identifying documents pertinent to his responsibilities that may have been missed in the computer searches. In these individual efforts, articles pertinent to the various activities of colleagues were regularly encountered. Each investigator was aware of the informational needs of his colleagues, and frequent communication among team members assured that colleagues would be apprised of articles of potential value to their tasks. Hence, the search for literature of concern to the preparation of a given volume of the STRES report series, while systematically compiled by those specifically responsible for that volume, was expanded through the efforts of the entire team.

To provide integration and focus to these literature search efforts, one group of the STRES team was specifically responsible for identifying articles of potential interest to all team efforts, as well as for preparing comprehensive abstracts of selected documents that appeared particularly valuable. These abstracts appear in a separate volume of the STRES report series.

More than 1100 documents were identified during these efforts as potentially relevant. These were further screened according to the currency and completeness of information provided and the integrity of the experimental and analytic methods used. As a result of this screening, approximately 400 documents were found to be useful for STRES purposes.

Site Visits

A considerable body of information was also obtained from organizations, both government and commercial, whose personnel are involved in the design, procurement, evaluation, management, and use of ATDs. ATD manufacturers, research and development agencies, and a commercial airline were visited in addition to Air Force, Army, Navy, and

Coast Guard military training sites. At each organization, extensive data were obtained through observations, interviews, and document reviews. The training organizations visited and the topics of primary interest at each are listed in Table 1. Table 2 lists non-training organizations that were visited and corresponding interest topics.

TABLE 1. TRAINING SITES INCLUDED IN PROGRAM SURVEYS

Sites and Units	Topics of Interest
Altus AFB, OK (MAC) 443rd Military Airlift Wing	C-5 transition training
Castle AFB, CA (GAC) 93rd Bomb Wing	KC-135/B-52 transition training
Denver, CO United Airlines Flight Training Center	DC-10/8-737/B-747 transition and continuation training
Eglin AFB, FL 33rd Tactical Fighter Wing	F-4 continuation training
Fort Rucker, AL U.S. Army Aviation Center	UH-1 and CH-47 undergraduate and transition training
Langley AFB, VA (TAC) 1st Tactical Fighter Wing	F-15 continuation training
Mobile, AL U.S. Coast Guard Aviation Training Center	HH-3/HH-52 transition and continuation training
NAS, Cecil Field, FL VP-174 and Light Attack Air Wing One	A-7E transition and continuation training
NAS, Jacksonville, FL VP-38 and Patrol Wing Eleven	P-3C transition and continuation training
Plattsburgh AFB, NY (SAC) 380th Bomb Wing	FB-111 transition training
Reese AFB, TX (ATC) 64th Flying Training Wing	T-37/T-38 undergraduate pilot training
Tinker AFB, OK (TAC) 552nd Airborne Warning and Control Wing	E-3A transition and continuation training

TABLE 2. SITES VISITED FOR MANAGEMENT, RESEARCH,
DEVELOPMENT, ENGINEERING AND COST SURVEYS

Sites and Agencies	Topics of Interest
Washington, DC Pentagon Headquarters, USAF	Management of Air Force ATD resources, and life cycle costs
Randolph AFB, TX Headquarters, ATC	Management of the use of ATDs in undergraduate pilot training, and life cycle costs
Langley AFB, VA Headquarters, TAC	Management of the use of ATDs in fighter aircrew training, devel- opment of ATD requirements, and life cycle costs
Eglin AFB, FL (TAC) Tactical Air Warfare Center	Procurement, development and evaluation of ATDs
Luke AFB, AZ (TAC) 4444th Operational Training Development Squadron	Development of training and ATD requirements
Williams AFB, AZ Air Force Human Resources Laboratory (AFHRL/OT)	ATD research
Wright-Patterson AFB, OH Air Force Human Resources Laboratory (AFHRL/LR)	ATD research
Fort Rucker, AL US Army Research Institute for the Behavioral and Social Sciences	ATD research
Langley, VA NASA Langley Research Center	ATD research
St. Louis, MO McDonnell Douglas Corp.	ATD design and research
Binghamton, NY Singer-Link Corp.	ATD design, procurement and evaluation
Orlando, FL Navy Training Analysis and Evaluation Group	ATD research and life cycle costs

TABLE 2. Continued

Sites and Agencies	Topics of Interest
Orlando, FL Naval Training Equipment Center	ATD research and life cycle costs
San Diego, CA Navy Personnel Research and Development Center	ATD research and life cycle costs
Orlando, FL US Army Project Manager for Training Devices (PM TRADE)	ATD research and life cycle costs
Hill AFB, UT (AFLC)	ATD life cycle costs
Holloman AFB, NM (AFTEC)	ATD life cycle costs
Luke AFB, AZ (TAC)	ATD life cycle costs
Offutt AFB, NE (SAC)	ATD life cycle costs
Scott AFB, IL (MAC)	ATD life cycle costs
Travis AFB, CA (MAC)	ATD life cycle costs
Williams AFB, AZ (ATD)	ATD life cycle costs
Wright-Patterson AFB, OH (ASD)	ATD engineering and life cycle costs

Specific objectives of the interviews and other data collection efforts varied, depending on the type of organization visited and the purpose of the visit. Manufacturers and research and development agencies were visited to assess current and projected technology and to review ongoing and planned efforts bearing on STRES program objectives. ATD using organizations were visited to obtain a variety of information related to types and effectiveness of training accomplished, uses of various types of devices in accomplishing the training, ATD design characteristics, worth of ATD ownership, and ATD life cycle costs.

STRES PHASE II REPORTS

Seven reports were prepared to document Phase II efforts and findings:

Caro, P.W., Shelnutt, J.B., & Spears, W.D. Aircrew Training Devices: Utilization. AFHRL-TR-80-35. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

Semple, C.A., Hennessy, R.T., Sanders, M.S., Cross, B.K., Beitn, B.H., & McCauley, M.E. Aircrew Training Devices: Fidelity Features. AFHRL-TR-80-36. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

Semple, C.A., Cotton, J.C., & Sullivan, D.J. Aircrew Training Devices: Instructional Support Features. AFHRL-TR-80-38. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

Allbee, K.E., & Semple, C.A. Aircrew Training Devices: Life Cycle Cost and worth of Ownership. AFHRL-TR-80-34. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

Prophet, W.W., Shelnutt, J.B., & Spears, W.D. Simulator Training Requirements and Effectiveness Study (STRES): Future Research Plans. AFHRL-TR-80-37. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

Spears, W.D., Sheppard, H.J., Roush, M.D., & Richetti, C.L. Simulator Training Requirements and Effectiveness Study (STRES): Abstract Bibliography. AFHRL-TR-80-38. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

Semple, C.A. Simulator Training Requirements and Effectiveness Study (STRES): Executive Summary. AFHRL-TR-80-63. Wright-Patterson AFB, OH: Logistics and Technical Training Division, Air Force Human Resources Laboratory, January 1981.

The content of the first four of these reports, i.e., ATD fidelity, instructional features, utilization, and cost and worth of ownership, is interrelated. As an aid to the reader in accessing related information, these four reports are cross-referenced. Within a single volume, other chapters where related information is discussed are referenced. When the cross-referenced information is in another volume, that volume is identified by abbreviated title (Fidelity, Instructional Features, Utilization, or Cost) as well as by chapter. For example, Utilization, Chapter IV, would indicate that related information will be found in Chapter IV of the report titled Utilization of Aircrew Training Devices.

As an additional aid to the reader, the Executive Summary volume reproduces the tables of content of all four volumes to provide a consolidated listing of topics addressed in each.

APPROACH TO THE STUDY OF ATD UTILIZATION

The present report documents the findings of that portion of the STRES Phase II effort having to do with utilization of aircrew training devices. The approach employed was described above, i.e., to compile information obtained through literature review and during visits to training, manufacturing, and research and development organization; to analyze that information; and to document it for the use of persons involved in the evaluation, management, and utilization of ATDs. Considerations of particular concern in the conduct of this portion of the STRES effort are treated in the discussion that follows.

Literature Review

Articles identified during the literature searches described above were screened for relevance to ATD utilization. Relevance was defined very broadly, however, for the perspective needed to answer questions related to ATD utilization frequently required knowledge of broader issues such as the design of ATDs and state-of-the-art simulator technology. Also, information concerned primarily with phenomena of learning and related instructional practices, both theoretical and applied, was needed in the assessment of reported ATD utilization per se. Of particular interest in the learning literature were conditions and practices that affect transfer of ATD training to aircraft, and the retention of skills acquired in ATD training over time.

Site Visit Activities

Activities of the utilization study team at the training sites identified in Table 1 included inspections of available simulators and related training aids, and observation of demonstrations of pertinent aspects of their capabilities and uses. The major portion of the time, however, was spent in intensive interviews with representative individuals from all aspects of the local training program. These personnel included flight and simulator instructors, pilots undergoing training, training program developers, and management personnel. A detailed interview guide was used (see Appendix A), and notes were recorded during and following the interviews.

Detailed information relating specifically to ATDs included: (1) training objectives; (2) training methods and techniques; (3) training effectiveness; (4) ATD and flight training program development and introduction; and (5) nature and qualifications of training personnel. As revealed in the interview guide, information pertaining to the

overall training programs was also acquired so that the utilization practices applying to ATDs per se could be put into perspective.

Interviews with key personnel were also the principal information gathering technique employed during visits to the sites identified in Table 2. The interview guides prepared for use at the training sites served as checklists for topics to be addressed at each agency. The thrust of these visits, however, was to obtain information about research in progress or planned, advanced simulation technology, and present and anticipated regulatory requirements and policies that could contribute to improved future ATD training programs. Information gained from these sources also broadened the perspective from which practices at training sites could be viewed.

The Problem of the Diversity of Information

A major goal of the site visits and associated observations and interviews was the identification of characteristics of effective and efficient ATD programs. These characteristics could include anything that promotes quality training, i.e., what is done, how it is done, and the conditions under which it is done. The scope of such a task was considerable. It ranged from determining how training requirements for ATDs are established and the quality of their fulfillment, to understanding purely administrative problems such as pipeline flows of students, instructor and student work load assignments, and provisions for ATD maintenance. In between were issues concerning training program design, preparation of instructional personnel, and the day-to-day implementation of instruction.

The scope of the task was further enlarged by the variety of types of ATDs that had to be considered. The skills to be taught using them range from piloting a high performance fighter to operating a boom for air-to-air refueling. The devices themselves included mock-ups, sophisticated high-fidelity OFTs/WSTs, and devices that fall between these extremes.

Bases for Evaluating Training Programs and Practices

With few exceptions, the ATD training programs observed during the present project had not been subjected to empirical evaluation to determine their effectiveness. Studies to assess the effects of specific program features or training practices in those programs were non-existent. Determining which of these ATD programs and practices were effective, and which were not, presented a particularly difficult problem for the study team.

Reviews of the literature did not provide a sufficient basis for making the required effectiveness determinations. Empirical studies of the effectiveness of individual aircrew training programs or of the contribution of ATDs used in such programs are rare. Most of the studies that have been reported were based upon rational criteria rather

than hard data, or they involved comparisons of alternate curricula and have relatively little generality beyond the specific device/program combination studied. Hence, the value of the research literature was limited primarily to suggesting factors that could potentially affect training outcomes.

Objective criteria for training effectiveness can be defined easily--e.g., the extent to which measurable course objectives are met; the extent to which ATD training transfers to aircraft performance as determined by initial skills in the aircraft or savings in post-transition training efforts; and the extent to which skills acquired in ATDs are retained or the amount of refresher practice required to maintain or reacquire necessary skill levels. These and other criteria can be applied, and methods for their application are well known. However, objective data corresponding to such criteria were not available for most of the ATD training programs surveyed during the present study.

In the absence of adequate objective data, other bases had to be employed to assess the effectiveness of ATD training programs and practices. Because of the limited opportunities of the study team to observe and analyze each program surveyed, it was necessary to rely heavily upon the judgments and observations of personnel who were involved in those programs concerning the effectiveness of each. To guard against possible positive or negative biases of these personnel, however, guidelines were established that would provide safeguards against uncritical acceptance of the reports of those personnel. Following these guidelines, the investigators formulated their own judgments of training effectiveness, and it is these judgments that provide a basis for the evaluations reported in subsequent chapters of this report.

The guidelines were stated in the form of six questions. The answers to these questions determined the confidence that could be placed in judgments and observations of the persons interviewed and provided a basis for the interviewers' own assessments of effectiveness. First, was there a consensus of beliefs among personnel in a given program regarding the effectiveness of ATD training generally as well as with respect to particular aspects of their programs? Second, could individual persons support their beliefs logically, or with formal or informal observations, by relating their judgments to specific ATD capabilities and training practices? Third, did the ATD capabilities and training practices cited in support of interviewees' judgments actually exist at the training site? Fourth, when viewed across sites, were there consistent patterns of judgments of training effectiveness associated with types of ATD capabilities and training practices? Fifth, had research shown the ATD capabilities or training practices at issue to have the effects attributed to them? And sixth, are the presumed results of training consistent with what could be expected with the practices used?

In addressing these questions, the investigators weighted the sixth question more heavily than any other single question. In doing so, they drew on their knowledge of the learning process and instructional technology. Numerous laboratory studies of learning have been reported each year for several decades. Various authors have presented digests of these findings adapted to ATD training (e.g., Miller, 1953; Wheaton, Fingerman, Rose, and Leonard, 1976; Wheaton, Rose, Fingerman, Korotkin, and Holding, 1976). The instructional principles summarized by these authors guided the investigators in evaluating the training practices they observed, in evaluating the beliefs of the instructional personnel they interviewed regarding the training effectiveness of those practices, and in reaching the conclusions contained in this report.

Furthermore, the questions were useful primarily for identifying possibly nonvalid judgments of the persons interviewed, rather than for confirming valid ones. For example, when instructors at one training organization blamed poor ATD results on particular device shortcomings, but at another site good results had been obtained with an equivalent or inferior device, little stock was put in arguments that rested on assumed values of the ATD capabilities at issue. Or, if an ATD feature, e.g., platform motion (or lack of it), was cited as the reason for training success (or failure), the research literature was consulted to see if such an inference was tenable.

All in all, opinions of those responsible for training generally appeared well conceived; and, in the absence of hard data substantiating the effectiveness or ineffectiveness of a particular program or practice, their opinions, qualified as described, provided meaningful bases for ascertaining effectiveness.

ATD Utilization Rates

At the beginning of this study, it was planned to collect data on rates of utilization of ATDs so that relationships between utilization rates and factors such as training effectiveness, device fidelity, and instructional features could be studied. This plan was dropped, however, because available ATD utilization rate data were suspect and could not be used for formal analyses. Specifically, the single most important factor found to influence rates of simulator utilization was direction from an authority that a device be used at a specified minimum rate. Instances were found in which mandated utilization rates were being achieved through practices that could not possibly yield effective training, e.g., logging device time while engaged in briefing/debriefing activities, taking coffee breaks, and performing maintenance functions. In one instance, an individual participated in a survey interview while reportedly logging simulator time in another building. The unit to which he was assigned, as well as some other units surveyed during the present study, apparently viewed use of a simulator as a "square to be filled" in their records, and utilization rates at mandated levels were being recorded through questionable practices when necessary.

The result was that official utilization rates approached 100% at all training sites, and it was not possible to estimate the proportion of time ATDs were used productively. There was ample evidence of beneficial use, however. Many instances were found, even at sites where abuses occurred, of utilization practices that were clearly productive in terms of judged training effectiveness and efficiency. Thus, observations of ATD utilization focused on quality rather than quantity of usage, and evaluations were made according to the criteria discussed in the preceding section.

CHAPTER III

THE LEARNING PROCESS AND ATD UTILIZATION

A well designed training program can be the difference between a marginal aircrewman and an excellent one, or between an unnecessarily expensive training program and one that is economical and efficient. To achieve these advantages, a training program must include a large number of features that foster effective and efficient instruction. Because a major factor in the effectiveness of training is the learner himself, no single program feature, and probably few combinations of several, are likely to be crucial to a program's success or failure. However, taken collectively, they will have a significant impact on the program's quality and efficiency.

ATDs can fill a major role both in achieving excellence in aircrew training and in reducing cost. In most training programs surveyed during this study, ATDs were valued primarily for the latter reason. They are generally cheaper to use than aircraft, so when they could be substituted for aircraft in training, economy resulted. However, properly used, ATDs can also be more effective than aircraft for many types of training. Furthermore, even when their value depends only on reduced cost, consideration should still be given to practices that will maximize training effectiveness and efficiency and thereby reduce costs even further.

The intent of this chapter, as well as Chapter IV, is to explore learning principles that can enable training program developers to make proper instructional use of ATDs. These principles are conceptual in nature and cannot be given simply as categorical rules that state what an instructor should do or when. Rules stating what to do in a given training situation would actually defeat the purpose of this report, because the application of learning principles must vary according to training programs and according to day-to-day instructional problems. The purpose here is to help personnel responsible for the utilization of ATDs derive sound instructional practices and approaches to solutions of training problems as they evolve. Judgments concerning the application of these principles will always be necessary, and the discussions which follow are intended to provide a foundation for structuring such judgments. It is believed that these discussions will enable personnel who are concerned with the effectiveness of ATD training to make better use of learning principles when they train aircrews.

TRANSFER AND ATD TRAINING

The ultimate value of ATD training depends on the extent to which skills learned during that training can be utilized later in an aircraft. Skills learned in ATDs must either be essentially the same as those

needed to perform in aircraft, or else they must enable a student to learn other or additional skills in aircraft more quickly than he could if he had not received ATD training. The process of subsequently using ATD skills in an aircraft is usually called transfer of training, or simply transfer. That is, skills learned during ATD training are said to "transfer" to aircraft.

Transfer is a complex process. It depends not only on what is learned, but on how and under what conditions the learning occurs. The complexity of transfer did not appear to be understood by personnel responsible for many of the ATD training activities observed during the present project. Instead, transfer was viewed as a simple, almost mechanical process. According to this view, transfer will occur only when: (1) the same stimuli are provided in the ATD that are provided in aircraft; (2) a student is able to do the same things with the ATD's controls that he would do with the controls in aircraft; and (3) the feedback he receives from operation of those controls is the same as it would be in the aircraft. Following these assumptions, the devices are often used to teach only those skills that can be performed in them the same way they are performed in aircraft.

Given sufficient stimulus and task fidelity, ATD performance will transfer to an aircraft. However, reliance only on stimulus and response fidelity is a restrictive approach to ATD design and utilization because it ignores some of the most important aspects of transferable skill learning. At the same time, this approach usually results in expensive capital outlays for high fidelity devices when in some cases high fidelity is not necessary.

To provide a foundation for a more comprehensive approach to ATD training, it is necessary to examine the concept of transfer itself. Three factors that affect transfer will be discussed: (1) cue development; (2) cue and response discrimination; and (3) generalization. These factors will then be related to what has been called "psychological fidelity," a concept basic to transfer of ATD training to aircraft.

The three factors discussed are closely interrelated. In fact, together they constitute the basic foundations of aircrew skill performances. They will be considered separately in this discussion, however, in order to emphasize the implications of each for ATD training, implications that would be less evident if they were all lumped together. (Chapter IV develops the implications of these factors as they apply to teaching procedures and conditions for ATD practice.)

Cue Development

Aircrews depend on cues to initiate actions, to guide their performance of those actions, and to signal when an action should be altered or ended. The first step in examining transfer, then, is to define "cue" and distinguish between a cue and a stimulus. Stimuli are

the bases for cues, but a stimulus is not a cue by itself. The term "stimulus" will refer only to a physical object or event that can activate a sense receptor. For example, when flying under turbulent conditions, g forces on the body stimulate internal receptors in the muscles, and instrument fluctuations stimulate the eye. The training task of the aircrewman is to learn the meaning of these stimuli, to derive pertinent information from them, so that the proper response can be made.

As these meanings are learned, stimuli become cues. In other words, a cue is a stimulus that has acquired meaning, i.e., it conveys information that is understood by the aircrewman. A goal of aircrew training is to learn the information content of task relevant stimuli so that precise actions can be taken. Even a "simple" automatic action such as adjusting input to the flight controls to counteract the effects of turbulence is in reality a complex process of using the information provided by motion and other cues. The effects of g forces on parts of the body, the subtle variations in pressures, the directions and magnitudes of instrument changes, etc., all must be "translated" into requirements for immediate, highly precise control inputs.

Such processes are complex and are often difficult to describe. For example, in maintaining position while receiving fuel from a tanker, the pilot knows that director lights indicate whether his vertical and fore/aft positions relative to the tanker are correct, and if not, the direction of any error. The lights (as well as other cues) may tell him, say, that he should be farther aft. However, he cannot even tell himself how much to ease off on the throttle. This latter knowledge is mostly a matter of "feel," i.e., interpretations of pressure and kinesthetic (movement) cues. While making the throttle adjustment, the pilot must continually monitor the lights so as to anticipate when, and how much, the throttle should be eased forward, thus avoiding an over-correction. The "feel" in moving the throttle is the cue that determines the adjustment he makes, which in turn is confirmed by information (cues) from the director lights that indicate changes in relative position.

The pilot's responses in this situation are not simply mechanical reactions to stimuli. They arise from interpretations of many cues and knowledge of the performance requirements indicated by those cues. In addition to visual cues, pressures and kinesthetic sensations from the flight controls provide further cues (information). These cues occur both during and after each control movement by the pilot. Each cue must be integrated with all others if skilled performance is to result.

Being able to interpret cues and to respond to them appropriately is the essence of aircrew skills. This role of cues as opposed to stimuli has a major implication for ATD use. The implication is that cue information available in a device, rather than stimulus fidelity per se, should be the criterion for deciding what skills or skill components are to be taught in a particular device. Even though some primary cues used

in the aircraft to perform a task may not be available in an ATD, examination may show that sufficient alternative cues are available. Nonvisual ATDs, for example, have been used to train some final approach and landing skills by teaching pilots to rely on cockpit instruments. The cockpit instruments can provide the alignment cues normally taken from outside visual references. The pilots can use, for instance, the Instrument Landing System (ILS) to establish runway alignment, glideslope, and distance to touchdown. Performance instruments must be crosschecked for maintaining airspeed and rate of descent, just as they would be in the aircraft. The approach can be flown to touchdown.

Transfer can be expected in terms of both the instrument crosscheck and the manipulation of flight controls during the approach and landing.

Cue and Response Discriminations

Skilled aircrew performance is dependent upon making appropriate responses to cues. Therefore, the two most important considerations in training are how one learns to interpret cues and how he selects the correct responses to be made to those cues. If personnel responsible for the design of ATD training programs have this information, teaching procedures and conditions can be designed to optimize the learning of aircrew skills in these devices.

Interpreting stimuli and selecting appropriate responses involve a process called discrimination. Discrimination is simply the recognition that a given stimulus or response is different from another stimulus or response. The appearance of the horizon at the top of a canopy, for example, can be discriminated (means something different) from its disappearance below the line of the instrument panel. If level flight is desired, given either of these cues, the corrective movement of the stick would be backward for the first condition but forward for the second.

The simplicity of this definition of discrimination should not suggest that discriminations are simple processes, or that they can be easily learned. The more complex the skill involved in aircrew performance, the larger the number of moment-to-moment, even instant-to-instant discriminations that must be made. Also, as task complexity increases, discriminations depend upon very subtle differences in patterns of numerous stimuli. A simple maneuver such as a bank turn, for example, becomes an increasingly complex task when it must be made to precise performance standards involving a specified degree of bank, g forces, and altitude maintenance. Ground and instrument cues must be interpreted in greater detail, and g forces must be "read" more specifically. Further, control inputs must be precisely coordinated with the constantly changing cues so that deviations from the desired path can be avoided. The difference between a novice and an expert when performing such complex tasks is that the expert has learned to derive more detailed information from the cues. He can discriminate subtle differences that a novice cannot. He can also translate the subtle meanings into equally subtle control inputs.

What the student is doing as he progresses from his first attempt to perform a bank turn to the time that he can perform this maneuver with precision is learning to discriminate the finer, more subtle cues and cue patterns that are used by the expert, and to make more precise responses to them. The speed with which he learns is itself an indication of how difficult the discriminations are to learn. He can learn very quickly, in fact, he needs only to be told, that pushing the stick laterally rolls the plane. However, mastering a steep bank instrument turn requires use of a host of constantly changing visual cues as well as pressure and "feel" cues arising from moving the controls to the necessary positions for maintaining bank angle, airspeed, and altitude.

The difficulties involved in learning to make discriminations can be reduced by judiciously controlling the sequences in which skills are to be learned. It is for this reason that attempts have been made to identify aircrew training skills hierarchies. The purpose of developing skills hierarchies is to determine which skills underlie, or are components of, skills higher in the hierarchy so that learning the higher ones can be made easier by building upon previously mastered skills that are lower in the hierarchy. For example, once a pilot has learned a basic loop, he can use the first part of this maneuver in performing an Immelmann turn. Learning the latter is made easier because the first half of the turn, so to speak, has already been mastered.

The same strategy can apply to learning discriminations. Complex discriminations can be built on separately learned basic discriminations. For example, formation flying requires mastery of complex distance cues, precise inputs to flight controls corresponding to subtle variations in those distance cues, and rapid reactions to the relative movements of another aircraft. While a student is not likely to master formation flying solely by learning such discriminations and reactions in isolation from each other, the overall formation flight task can be learned more easily if the student has previously mastered distance estimation tasks and the coordination of control inputs in response to visual cues. Furthermore, once the student has learned the distance estimation skills necessary for formation flight, these discriminations can be used to guide his inputs to flight controls when he is approaching a tanker for refueling, or even when closing on a target for weapons release.

ATDs have a distinct advantage over aircraft in aircrew training in this respect. This advantage derives from the fact that ATDs are adaptable to teaching cues and response discriminations at the time they can be most effective for learning other, more complex discriminations and skills. Cues and responses cannot be broken down during flight in the same ways they can be in ATDs. For safety reasons, basic aircraft control skills must be mastered before most other skills can even be attempted. In the ATD, the sequence of individual skills can be taught according to instructional efficiency rather than safety requirements. Discriminations underlying skills can be taught in ATDs at times and in ways that promote the most efficient development of skills.

Any number of previously learned discriminations can be useful in learning new discriminations. An experienced pilot can transition to an unfamiliar aircraft more easily than can an inexperienced pilot because he has previously learned to discriminate among many cues and response requirements that are similar to those encountered in the new aircraft. However, previously learned discriminations vary in the extent to which they can help in learning new ones. "Feel" cues learned in an ATD of low dynamic fidelity, for example, are not as helpful in learning to fly an aircraft as are cues learned in a device with high dynamic fidelity. In fact, the cue discriminations learned in a poorly designed device may actually result in negative transfer, i.e., they may interfere with performance in the aircraft. Thus the experience level of pilots undergoing continuation training may enable them to benefit from use of low fidelity devices, but if those devices involve inappropriate or erroneous cues and responses, the pilots might acquire skills that would have to be "unlearned" in order to fly the aircraft, or at least it may be necessary to learn to ignore certain aspects of them.

Generalization

"Generalization" refers to the use of previously learned skills in situations that are different from the situations in which they were learned. Generalizations are so obvious that the need to consider them in training is often overlooked. Without generalization, our day-to-day experiences would be without meaning or context. We would have to learn anew to cope with every experience we encounter. Competence in aircrew skills would not carry over from one situation to another, or even from one day to the next. In fact, much of what is usually termed "memory" or "retention" is really an example of the generalization of prior learning to subsequent situations.

Generalization occurs to the extent that a given situation is interpreted as similar to a previously experienced situation. Similarity is thus based on cue information, i.e., the meanings conveyed by the stimuli present in the two situations. Procedures learned in a low fidelity cockpit mock-up can be generalized to (i.e., performed in) a high fidelity simulator or an actual aircraft because although the two may differ as actual stimuli, the meanings of the cues present in the mock-up are similar to the meanings of corresponding cues present in the aircraft. Pretending to perform a complex procedural task by pretending to push buttons and position switches in a mock-up where the buttons and switches are represented symbolically can have the same meaning (and training value) as actually performing these actions in the aircraft.

Thus, all cues learned in an ATD can be generalized to, i.e., subsequently utilized in, aircraft to the extent that the cues have the same meanings in both vehicles. The physical stimuli can vary. Instruments can be of different sizes or configurations; visual displays can resemble geometric patterns more than real world scenery; platform motion systems can (as they must) be restricted to accelerations of brief

durations and movements of small distances. Even cues associated with the training process itself can vary. Flights can be interrupted with periods of freeze or playback; a landing approach may be practiced repeatedly without ever following through the complete task of first flying to the point to begin the approach; a single instructor can provide voice simulation of multiple ground stations and other aircraft. These and a host of other "unrealistic" or "low fidelity" conditions can be imposed in order to achieve ATD training at reduced costs, provided the similarity of meanings of cues in the devices and in aircraft can be maintained.

The fact must be remembered that even the most sophisticated ATD provides at best a low fidelity representation of the real world mission of the aircraft simulated. Therefore, it is important that ATD training focus on generalizable meanings of the cues they can provide. In other words, insofar as device features permit, a student should learn to use cues that he will need in order to perform in the aircraft by concentrating on the meanings of stimuli available in the ATD rather than upon the physical characteristics of those stimuli. Some currently existing simulated ground visual scenes, for example, are composed of nothing more than a checkerboard pattern of light and dark areas. Yet, as Stark (1976) reported, experienced fighter pilots flying the Simulator for Air-to-Air Combat (SAAC) used such scenes effectively as cues to direction and speed of movement while performing combat maneuvers. If pilots can use such checkerboard patterns as cues to the performance of tasks requiring actual ground scenes when performed in flight, there must be common meanings between the two kinds of stimuli. Although cue values for an experienced pilot and for a student in training may differ, the student could almost surely learn some cue interpretations from the simulated scenes that he would be able to apply to the cues encountered during subsequent training in aircraft.

Teaching generalizable cue interpretations is stressed in Chapter IV. It is also emphasized there and in Chapter V that a student will need to practice in the aircraft using cues learned in ATDs, for only through such practice will he learn to discriminate cues that are common to the ATD and the aircraft from those that are not. With little or no experience in flight, for example, it is likely that a student would probably use some ATD stimuli peculiar to the checkerboard nature of the visual display and perhaps miss the important cues available from such a display. Therefore, to ensure generalization of appropriate cues, he will need some experience in aircraft as an important part of the learning process.

The learning discussed in the paragraph above might be described as generalizing cue discriminations, a process that underlies all skill learning. This process was implied in the earlier discussion of hierarchies, i.e., building new discriminations on those already learned. Cues and responses associated with previously learned skills become incorporated in new skills through this process. The first half of a

loop is used to initiate an Immelmann turn and a Cuban-eight. The sequence of thought, perceptual, and kinesthetic cues previously learned in association with the loop, and the related sequence of coordinated responses, are generalized to become components of different tasks. The Immelmann and Cuban-eight are not entirely new tasks. They build on one that is already familiar.

A major difference between training as it must occur in an aircraft, and as it can occur in an ATD, is the extent to which training devices permit concentrated practice on smaller and more specific components of skills. Executing a power-off stall cannot be done piecemeal in an aircraft. On the other hand, if a student has trouble decelerating at the proper rate or not over-reacting to a "mushy" stick, ATDs with re-initialization capabilities can permit intensive practice on the troublesome cue-response discriminations without the time or cost involved in completing the entire task during each trial as would be required in an aircraft. Then, a given degree of stick "mushiness" can guide the learning of power control, or vice versa. Or, as in the earlier example of learning to discriminate distance cues, changes in a broad range of distances can be presented in concentrated ATD practice sessions. The visual discriminations learned through such concentrated practice can then be generalized as needed for formation flight, approaching a tanker, or closing on a target. These more complete, operational tasks could then be practiced, either in an aircraft or an ATD, with minimum effort devoted to learning to discriminate crucial visual cues.

Generalization of the discrimination among cues is the basis for the generalization of responses appropriate to those cues. If a response has become associated with a cue, and refined and honed according to the requirements dictated by the cue in all its subtle aspects, then it will be available to the extent the cue itself is recognized in a subsequent situation. The challenge in ATD training is to teach cue discriminations in such a way that cue subtleties remain clearly recognizable in the new, different stimulus complex presented in an aircraft. When ATD training accomplishes this, aircrews will transfer the associated responses to the aircraft as well.

Sometimes even apparently well-learned ATD-based skills are performed incorrectly when first practiced in an aircraft. Such disruptions are not due so much to an inability to generalize responses learned in the device to the aircraft as to the interfering effects of new aircraft cues which did not exist in the ATD. The new cues call forth different, and possibly even competing, responses. Anxiety, for example, introduces a host of internal reactions that cue responses different from those required for precise performance. The extraneous responses interfere with the desired ones, so it may appear that ATD training was of limited value. However, when the new cues are accommodated, i.e., when they can either be ignored by the student or

assimilated as extensions of ATD cues, the ATD-learned responses can emerge with their original precision.

Adaptation by pilots to aircraft motion during an intricate maneuver illustrates this point. Sustained motion cannot be experienced in currently available ATDs. Thus, no matter how well aircraft control responses are mastered beforehand in an ATD, the actual continuing motion of an aircraft will introduce stimuli that were not present when the responses were being learned. If a pilot associates a given control input with the cessation of g forces resulting from the limited movement necessary in an ATD, the sustained movement of an aircraft may well be interpreted as not enough (or too much) control input. In attempting corrections, precision of control will suffer a decrement. However, once the pilot adjusts to the additional motion stimuli found in the aircraft, the responses he learned in the ATD will not be disrupted. The ease with which those responses can be incorporated into his performance in the aircraft will be determined largely by the extent to which he mastered instrument or visual cues and cue-response relations in the ATD. If ATD-learned discriminations are of the right sort, and are sufficiently mastered, the meaning of motion or other stimuli can be learned by relating them to the cues that are already known.

Two examples will illustrate further the role of generalization in ATD training. During a visit to a training site, an ATD instructor commented, "Our simulator students don't do as well on navigation during checkrides as the ones that were trained in the aircraft, but we think we're turning out better navigators." He was probably correct. Students trained only in the aircraft had very few places to land--the same place where they took off and a few nearby airports. They received intensive practice using instruments and other navigational aids to approach these few airports. On the other hand, students in the simulator practiced a larger number of different simulated approach problems, each involving the use of different navigational information. Due to restrictions on training time, however, no one simulated approach could be mastered to the extent permitted by practice of the "home field" approach in the aircraft.

The instructor quoted above was saying, in effect, that if an approach problem were presented that had not been practiced by either group, the simulator students would be superior in their performance. There are excellent reasons for accepting the instructor's subjective impressions, assuming the training was properly conducted. The implied objective for all students was to be able to respond to appropriate cues when approaching any airport. Simulator students practiced a large variety of such tasks. Thus, they practiced applications of their knowledge of navigational procedures to different cue complexes, i.e., they learned to discriminate among a greater variety of navigational and approach cues and thus were better prepared to generalize their skills to new situations. In effect, they were practicing the process identified here as generalization. It is axiomatic that a person learns to do

whatever he practices during training. If generalization is practiced, generalization will be learned.

The aircraft-only trainees also got some practice in making discriminations and generalizations, although their approaches were mostly to a single landing field. Even at that field, they undoubtedly experienced some variations in conditions from approach to approach. Even so, it is unlikely that these pilots achieved the general operational competence required to land at a variety of airfields as early as those whose practice involved a greater range of cue-response generalizations during ATD training.

At another training site, a T-40 device was used by KC-135 and B-52 pilots for practice and training in instrument flight. The T-40 is an instrument trainer that was not designed to simulate either of these aircraft. What this device provided were opportunities to practice a variety of instrument flight and navigational tasks and to learn to make the discriminations required by those tasks. The practice concentrated on cue and response coordinations that could be generalized regardless of the physical features of the device itself.

The training conducted in the T-40 illustrates an important point regarding the use of ATDs. Meaningful practice of the discriminations and generalizations needed to perform in some flight tasks does not require strict task, much less physical, fidelity. What one actually does in the T-40 cannot be identical to what is done in the KC-135 or B-52 simply because the switches and controls, their dynamics, and their configurations are different. Practice can be productive in such devices nevertheless, because the meanings of the instrument flight and navigational cues present in them compensate for lack of stimulus and response fidelity. In fact, the majority of experimental studies demonstrating transfer of skills learned in devices to training or operational aircraft have involved such devices.

Transfer and "Psychological Fidelity"

The design of many ATDs and their use at some of the units surveyed during the present project reflect an apparent belief that the stimuli and associated responses in an ATD must be similar, or even identical, to those in the target aircraft if skills learned in the device are to transfer to the aircraft. Beliefs such as this are based on "similarity" explanations of transfer. These explanations hold that the amount and kind of transfer depend upon the degree of stimulus similarity and on the degree to which responses are similar or antagonistic. Positive, i.e., desirable, transfer occurs when ATD and aircraft stimuli and associated responses are similar. On the other hand, if stimuli are similar and associated responses are different, negative, i.e., undesirable, transfer would result. No transfer occurs when stimuli are totally dissimilar, regardless of responses.

According to similarity explanations, maximum positive transfer occurs when stimuli and responses in the ATD are identical to those in the aircraft. Thus, transfer from one F-15 to another is very high, because all stimuli and responses would be virtually identical. However, transfer from an ATD to an F-15 would depend on the degree of physical fidelity of the device. Maximum negative transfer would occur when stimuli are identical but responses are antagonistic. For example, if in order to bring the nose up, a forward stick movement were required in a simulator, instead of a rearward movement as in the aircraft, transfer would be negative, because the two responses would be antagonistic in spite of the physical similarity of the simulator stimuli to those of the aircraft. Also, some degree of negative transfer would be expected when ATD responses differ noticeably in magnitude, or when the ATD and aircraft differ in reactions to control inputs.

Similarity explanations of transfer notwithstanding, it has been established in many transfer studies that device and aircraft stimuli and associated responses need not be physically similar for transfer to take place. For example, Prophet and Boyd (1970) demonstrated that cockpit procedures training in a cockpit mock-up made of plywood, photographs, and dowel rods transferred to an aircraft as well as did corresponding training in a device of high physical fidelity. (Training in each device was comparable to corresponding training in the aircraft itself!) To account for effective training with such devices, it is necessary to explain transfer as dependent on something more than strict stimulus and response similarity. Explanations must somehow involve the equivalence of stimulus and response meanings.

Explanations based upon meaning emphasize cues rather than stimuli, that is, information provided by stimuli rather than physical characteristics of the stimuli themselves. According to these explanations, transfer occurs when stimuli and associated responses in an ATD can be interpreted by an aircrewman as equivalent to corresponding stimuli and associated responses in the target aircraft. The term "psychological fidelity" or "psychological realism" (as opposed to physical fidelity or realism) is sometimes used to denote this equivalence in meaning. A device may be useful for training in spite of its physical dissimilarities if it has high "psychological fidelity." In other words, there is a psychological process that compensates for a lack of stimulus and response fidelity.

How this psychological process operates is illustrated in an example provided by Bunker (1978). He asked experienced pilots to fly a simulator with a new computer generated image display system. These pilots had difficulty in using simulated ground scenes that contained curved roads and fields with a variety of shapes and sizes, two features that are characteristic of actual ground patterns. When all fields were made square, and all roads parallel or perpendicular, however, the same pilots had no difficulty using the simulator scene. Citing research literature on visual depth perception, Bunker pointed out that perceived

distance is determined by gradients, that is, by how parallel straight lines appear to close toward each other as they are more distant, or by how apparent speed relative to ground objects changes with altitude, etc. In brief, Bunker noted that pilots do not key on "naturalness" of a ground scene, but abstract from it certain characteristics such as gradients that they have learned to interpret. Thus, to the pilot, a scene is "psychologically real," and he can use it as he would use an actual scene, if he can readily discriminate those characteristics on which he has learned to depend. Apparent physical realism that does not include such cues cannot serve the same purpose for him.

The preceding discussions of cue development, cue and response discrimination, and generalization identified elements in the development of psychological processes upon which psychological fidelity or realism depends. In Bunker's example, visual scene gradients become cues as pilots learn to abstract, i.e., discriminate, them from fields and roads as such. A road is not a road as a depth cue. Rather it is two lines that appear to converge in the distance. Once a pilot discriminates the gradient from the air, he can readily generalize it to any ground scene by scanning the scene for this meaningful cue.

This overall psychological process of seeking and recognizing familiar cues in changing situations is an instance of "mediation." That is, the generalization of previously learned discriminations to a situation at hand is an intermediary process that provides meaning for the situation. It comes between, or mediates, the acts of sensing a stimulus and responding to it.

Mediation occurs any time a person interprets a stimulus and acts according to the interpretation. In this sense, even well habituated, mechanical actions of aircrew are mediated. Minor control adjustments to turbulence, for example, are not simple reflex reactions originally. They must be learned, and the learning involves a complex processing of information from various stimuli. Magnitudes of g forces are represented as tactile, muscular, and vestibular stimuli; extra-cockpit visual references add other stimuli, as do instrument changes. These stimuli must be interpreted and "translated" into types and magnitudes of required control adjustments. In turn, the control adjustments have to be guided by another complex of stimuli, i.e., the "feel" of controls and their movement. "Feel" includes numerous pressure stimuli in the hands and feet as well as those arising from moving these members.

Mediations underlie all skills, and mediational explanations of transfer are important in ATD training because they focus attention upon related learning processes rather than on the physical features of the device and the responses that can be performed in it. During training, the aircrewman does not simply react to stimuli presented by the device. Simply performing tasks in the device, even an exceptionally high fidelity one, does not constitute efficient training. Instead, ATD training should emphasize the mediating processes that enable students to

establish cue meanings and cue and response discriminations, and to generalize skills being learned in the device to the stimulus situation to be encountered in the airplane. A high degree of physical fidelity in the device may or may not be needed. The point is that ignoring the role of mediation in ATD training, and depending solely upon physical similarity as a basis for transfer, limits device training to those skills associated directly with the device's level of physical fidelity.

Effective training can be obtained in devices that, to one degree or another, are dissimilar to the aircraft simulated. For example, photographs of cockpit switches in the mock-up built by Prophet and Boyd (1970) symbolized the real switches in the aircraft, and the symbolic process of pretending to reposition those switches was just as useful when learning to perform cockpit procedures tasks and their sequences as actually performing them in the aircraft. Although there was little physical stimulus similarity between the photograph and the switch, or between pretending to move the switch in sequence and moving it, the psychological similarity of the acquired meaning of these stimuli and responses was sufficient for the substitution of one for the other during training.

Furthermore, the necessity for written materials and oral instruction in aircrew training illustrates the extensive dependence on symbolic meanings. With appropriate prior experience, "mental" or imaginative rehearsal can be effective for learning or improving performance in many tasks. Following their extensive review of literature on learning, Wheaton, Rose, Fingerman, Korotkin and Holding (1976) stated that for some skills, mental rehearsal could even be substituted on a one-to-one basis for some practice trials. The requirement for effective training in ATDs is that during practice, critical aspects of the operational conditions be represented in the experience of the learner. The representations themselves may be derived from high fidelity stimulus conditions, substitute stimuli that have acquired appropriate meanings, a printed page, or even a verbal instruction beginning with "Let's pretend..."

The importance of mediation in ATD learning becomes even more obvious when one considers the pervasive role of verbal mediation--a process with no objective fidelity whatsoever--both in training and in operational performance. The profound role of language in learning to discriminate among cues and to generalize those discriminations is easily established: Two or three brief, cryptic lines of clearance are sufficient to direct an aircraft to a distant airport via an almost unlimited number of routes. Such is possible because the clearance employs discriminative language that has been mastered by aircrew and air traffic control personnel, and they can generalize their ability to discriminate the cues contained in a clearance to almost any new routing task that confronts them. In short, they are transferring previously learned responses to new stimuli because they are able to discriminate the essential information in the clearance.

Without language, aircrew training would be a chaotic enterprise. Consider training a student without any words, oral or written, to explain things to him or tell him what to do or how to practice. Not only does the instructional process itself depend upon previous mastery of this mediational system, but the student must learn new uses of it. He must use language overtly for communication during task performance; but probably more important, he must employ language covertly to clarify most of the cues he will use, and to guide his discrimination of cues and the responses associated with them. Furthermore, this last usage of language often increases as an aircrewman matures. For example, when a fighter pilot was asked how he decided on various courses of action, he described several circumstances, the cues he sought, and how he talked to himself about them. In attacking another aircraft he would say, "He's in a 2-g turn so his radius will put him over there. I'll set up an Immelmann turn." After several similar examples, he broke off with, "I talk myself through a lot of things."

Because of the role verbal processes can play in complex performance, such as air combat maneuvering, and because verbalizations can be brought under conscious control, language is a prime mediational vehicle for teaching even nonverbal perceptual-motor skills. Eventually, a pilot may learn to use, say, only visual perceptions of the rate of change of a compass heading to guide some particular control input. But, rate of change is vague at best to a novice. He must first read the compass as headings or degrees--words--while probably saying to himself, "That's too much; that's about right." If one teaches the novice how to use language as a mediational vehicle while in training, i.e., to talk to himself about what to notice and what to do, he will be able to learn more rapidly to discriminate perceptual and kinesthetic cues and associated motor responses. The end result will be a well established coordinated, complex habit that eventually may require little or no verbal guidance.

The importance of such mediational processes are generally recognized among ATD instructors, at least intuitively. However, provisions in aircrew training for mediation per se, as opposed to overt task performance, are not as common as one might expect. It is often said that a student should be "encouraged" to verbalize to himself what he is doing in performing a task, but few instances were noted in the ATD programs surveyed during the current project in which a trainee was told what he should say or how to select what to talk about. The verbalizations, of course, should concentrate upon selection (discrimination) of appropriate cues, including ongoing kinesthetic feedback from control movements. In other words, aircrew trainees should be taught to verbalize the discriminations that they are learning to make among such cues.

A possible use of the ATD instructional feature Freeze illustrates a potentially valuable training practice involving verbal mediation. When a student goofs during a maneuver, an instructor typically freezes the

action and discusses what the student did wrong. Typically, in the training activities observed during the current project, the focus in such discussions was upon objective cues, the failure to interpret them, and the resulting overt actions. For example, the instructor would say, "On this dive bomb delivery, your airspeed was too high. You have to check your airspeed and adjust it in order to have accurate bombs."

To enhance the effectiveness and efficiency of ATD training, equal emphasis should be given to how the student is processing information, how and why he selected or failed to select particular cues, and what he should do to improve the processing of the information he obtained from those cues. For example, the instructor might say, "On this dive bomb delivery, you allowed yourself to become preoccupied with positioning the bomb sight. You left the airspeed indicator out of your cross-check. This time note the airspeed immediately after you have established your dive. Retard the throttle half-way to idle to maintain your delivery airspeed. Use this rule: Assume you will gain twenty knots for each 1000 feet that you descend until you retard the throttle."

In discussions of the use of mediation during aircrew training, several instructors expressed concern that students would learn to depend upon the verbal mediating for guidance and would not develop skill in performing the task being aided. They were concerned that the students might be learning only how to interpret situations and to derive cue meanings but not how to recognize and respond automatically to potentially threatening situations. There is no such danger. Mediation is useful in training, but if the mediation is not necessary to performance of the task being learned, the verbal mediating will disappear after the task is learned. This occurs because once the task is learned, the mediation is no longer useful, and steps in skilled performance that serve no purpose soon drop out.

Mediation of all types permeate every aspect of aircrew training and performance. Therefore, instead of leaving mediational processes to develop on their own, as is often the case among instructors who rely heavily on ATD physical fidelity as the basis for learning, these procedures should be specifically targeted in training objectives. When left up to the students, any one or more of a number of cues may be selected for an action, and they may be interpreted according to a variety of different schemes.

SUMMARY

There are no mechanical procedures for the application of learning principles to ATD instruction, because these principles are conceptual in nature and cannot be given as categorical rules. Judgments concerning their application are required. A foundation for structuring such judgments is provided in this chapter through examination of learning processes and the concept of transfer.

The ultimate value of ATD training depends on the extent to which skills learned during that training transfer to the aircraft. Three factors affecting transfer were discussed: (1) cue development; (2) cue and response discrimination; and (3) generalization. Being able to interpret cues and to respond to them appropriately is the essence of aircrew skills. Thus, ATD instruction should focus on teaching aircrewmembers to learn cues (i.e., the meaning of physical stimuli), and to derive pertinent information from them so that the proper response can be made. The aircrewman must learn to discriminate, i.e., to recognize and select, the cues and responses appropriate to a given task. He must then generalize these to situations different from the situations in which they were learned.

While the focus of all aircrew instruction is on teaching the discriminations underlying aircraft performance, ATDs have a distinct training advantage over aircraft in that discriminations can be taught in ATDs at times and in ways that promote the most efficient development of skills. Furthermore, it is the cue information available in an ATD, rather than stimulus fidelity per se, that should be the criterion for deciding what skills or skill components are taught in it. Since transfer is based on cue information, all valid cue interpretations learned in an ATD can be generalized in both vehicles. Thus, it is important that ATD training focus on the generalizable meanings of the cues they can provide.

Transfer depends on meanings, whether ATD stimuli and responses are realistic or not. "Similarity" explanations of transfer, upon which many conceptions of ATD training value rely, focus only upon the physical similarity of training devices to aircraft, and upon their capability to provide for task performance as it is actually done in aircraft. When ATD training objectives are determined by dependence on physical and task fidelity, ATDs cannot be used to their full potential. A complex psychological process called mediation permits performance in devices of various fidelity levels to acquire meanings similar to the meanings of corresponding performance in aircraft. Thus, through mediation, ATD training is not limited to device-aircraft physical similarity. Through mediational processes such as language and mental rehearsal, the effectiveness of all ATDs is enhanced.

This chapter focuses ATD training on the mediational foundations of aircrew performance. Chapter IV, which is concerned with training practices and conditions that promote learning cue and response discriminations, their retention, and their generalization, continues this focus. Chapter V, which builds both on this chapter and Chapter IV, discusses the structuring of ATD training to assure that it is effective and efficient.

CHAPTER IV

THE CONDUCT OF ATD TRAINING

Aircrew skills are acquired through the learning processes described in Chapter III. Whether the skills are acquired efficiently depends upon how the practice is conducted. This chapter provides information on how ATD training should be conducted. Chapter V draws on this information in discussing the structure and scheduling of ATD training.

The acquisition of aircrew skills through instruction and practice in ATDs is a complex process. For ATD training to be efficient and effective, the learner must acquire certain knowledge, his actions must be guided, and he must be informed of the correctness of his actions. These three factors--knowledge acquisition (i.e., cognitive training), informing the learner about his actions (i.e., feedback), and guiding the learner (i.e., guidance)--underlie the conduct of effective instruction in ATDs and in all other training media.

COGNITIVE TRAINING

Effective and efficient ATD training depends upon preparation for learning. That preparation takes place in classrooms, in briefings, in discussions, in ATDs and aircraft, and in a variety of other formal and informal settings. It consists of learning about the cues and responses that must be discriminated; about the purposes of those discriminations; about the meanings of symbols that will substitute for aircraft cues and responses in ATDs; and about the subtle differences between ATDs and aircraft that must be noted before transferring to aircraft. Much of this preparation involves cognitive processes, i.e., thoughts, ideas, mental images and concepts that are both verbal and nonverbal. Basically, it consists of the cognitive foundations upon which ATD training, and ultimately, aircrew performance, rest.

Cognitive Training in Skill Acquisition

Cognitive training should be employed systematically during aircrew training to provide a general context for skill performance and to aid in learning particular cue and response discriminations. Some examples of aircrew training activities that have made effective use of cognitive training may be found in the aircrew training literature. For example, Williams (cited in Fitts and Posner, 1967) conducted detailed discussions with novice pilots of each maneuver to be practiced on a given flight. The focus was primarily upon cue and response discriminations. The exact sequence and relative timing of each cue and response was delineated, such as "When you cross the fence at the end of the runway, reduce your power to idle." The students undergoing this training soloed in an average of 3-1/2 hours in an aircraft compared to 10 hours for a control group. Prather (1972) used only an audio tape-recorded analysis of a

landing task for similar training sessions with a group of T-37 students. The instruction on the tape emphasized what to do, when, and why. Following this training, these students were rated significantly higher on landing procedures and techniques than were students who did not receive it.

Cognitive training need not be restricted to verbal information. For example, Smith, Waters, and Edwards (1975) prepared and successfully validated a training "package" for the T-37 overhead traffic pattern that employed slides and 8mm motion pictures to teach students to discriminate the visual cues associated with that maneuver. Commercial airlines have made considerable use of nonverbal cognitive training, employing a wide range of media resources to prepare students to learn cue and response discriminations during subsequent ATD training sessions (Browning, Copeland, Lauber, Nutter, and Scott, 1972; see especially Appendix A).

Virtually all of the aircrew training processes noted during the current project made extensive use of cognitive training. In academic training, for example, students acquire a knowledge of the tasks they are to perform. They are briefed before flights, and considerable amounts of "homework" are completed prior to those briefings. They are encouraged to rehearse tasks mentally and to think them through before attempting them in ATDs, and again after they have been practiced. Debriefings following training consist of analyses that highlight the adequate aspects of performance as well as problems to be resolved during subsequent training. These training activities provide criteria for task performance, identify purposes of tasks, provide contexts for their performance, and provided bases for decisions to be made during training and subsequently during operational mission activities.

Cognitive training plays a significant role during ATD training as well as in preparation for it. The reminder, "Think about what you are doing," is frequently employed in the devices to call forth a conscious awareness of experiences during learning so that cue and response characteristics will stand out. In the programs judged more effective, the students are being guided concerning what they are to think about in such situations. For example, when 4-1/2 g is achieved in an F-4 at the beginning of an overhead maneuver, instructors reportedly have been instructed to tell students to think "feel" at this g level. A number of instructors encourage students to "talk themselves through" the performance of tasks they were attempting to learn, and give helpful guidance as to what to talk about, e.g., the cues to which the students should respond, when and why. For example, in learning when to depart from a standard loop to complete an Immelmann, one instructor said he had his students verbalize the cues that indicate the point for change and the consequence of delaying or initiating too soon the actions required to complete the Immelmann.

In all of the studies cited above and in the examples of uses of cognitive training noted in the current project, the key to successful training was the systematic, highly specific identification of cues and

responses that the students would encounter during subsequent practice in ATDs or aircraft. The verbal and perceptual information the students received during such training became a basis for the students to guide themselves in seeking and interpreting cues that they had to learn to discriminate.

Cognitive Training in ATDs

The value of ATD training in general depends upon the use of cognitive processes to equate (psychologically) the cues and responses learned in ATDs to those occurring in aircraft. ATDs are physically different from aircraft, and the lower the fidelity of an ATD, i.e., the more symbolic the cues and responses involved in its use, the greater the need for such equating mediation while practicing with it. It is through mediation that ATDs of all fidelity levels, from weapons systems trainers to paperboard mock-ups of aircraft cockpits, can be used effectively as trainers. In such devices, the student performs symbolic actions in response to symbolic cues. By attending to the meanings of these actions and cues, instead of their physical characteristics, transferable discriminations of cues and responses can be practiced and learned, and their ATD-peculiar physical characteristics can be ignored.

But regardless of the fidelity of an ATD, an awareness of operational reality should be maintained. Students training in ATDs should be thinking constantly, not of what they are doing in ATDs, but of the meanings and effects of their actions with respect to performance in the aircraft. What sounds are heard when an engine starts or when the throttle is pushed forward? What are the disorienting effects of a Cuban-eight and what cues must be relied on? What information is needed to perform a bomb-toss maneuver and what cockpit instruments can provide it? It is important that academic instruction and pre-ATD session briefings stress these meanings so that the student can attend to them when attempting to learn the skills involved.

In addition to explanations of performance requirements, preparations for ATD training sessions should anticipate and guard against a student's relating what he does during ATD practice only to the device itself. When cues or cue patterns are only partially represented in an ATD, the missing portions of cue complexes that are necessary to performance in the aircraft should be described, and their relations to the cues that are available should be explained during the briefing. For example, in many maneuvers in high performance fighters, g cues must be coordinated with the "feel" of controls for smooth, accurate gun-tracking performance. Current state-of-the-art ATDs cannot duplicate all elements of these cues. Therefore, the student should think about their occurrence in the aircraft while practicing in the ATD, and he should recall them during subsequent ATD sessions as often as necessary to maintain an awareness that they are part of the cue structure he is learning.

When cues are only partially available as is the case with some cues in all present day ATDs, students should be made aware of the cue components that are missing. For example, the changing angularity of ground reference lines while an aircraft is in motion can be represented by currently available computer generated visual simulation systems, while changes in the blocking of views of one ground object by another sometimes cannot. When practicing with such a symbolic visual system, the student should be instructed to focus on angularity cues (and told what they are), but to keep in mind that in actual flight he would also experience additional blocking cues arising from movement of the aircraft past objects.

For ATD training to transfer to aircraft, the information value of cues in the two must be comparable, and the responses learned in the ATD must be usable in the aircraft or adaptable to it. Since ATD and aircraft cues and responses frequently are not identical, it is important that those that are common to both ATDs and aircraft be discriminated from those that are unique to the ATD, since recognition of cue similarities and differences are necessary for effective use of ATDs. An important role of cognitive training is to make these discriminations obvious. (Analytic techniques for identifying common and unique cues and responses can be found in Caro, 1970.)

It was noted during the present project that ATD instructors do call the attention of students to differences between ATD and aircraft. However, the instructors' inclinations often are to avoid practicing tasks in ATDs where the differences occur instead of dealing with the differences as a cognitive discrimination training requirement. Even worse, some instructors were found to emphasize the inadequacies of the ATD and thereby communicate to students that the practice session was of little importance.

Several instructors interviewed expressed concern that even if the student has been instructed as to the differences between a particular device and an aircraft, he will adapt his skill to the peculiarities of the ATD, and negative transfer to the aircraft will result. That is, these instructors were concerned that the skills a student takes from a low fidelity ATD to an aircraft will interfere with proper performance in the aircraft. This risk certainly exists, but it can be minimized if the student learns to discriminate the differences between the ATD and the aircraft and attends to those differences during practice in the device. With prior knowledge of differences to expect, he can key quickly on aircraft characteristics and correct for the negative transfer while profiting from the ATD learning that was appropriate.

FEEDBACK

"Feedback" refers to cues that inform a learner as to the results or effects of his actions. Feedback has two important roles during ATD training: (1) to maintain a student's motivation to learn; and (2) to

inform the student of the appropriateness or inappropriateness of his interpretations of cues and his responses to those cues.

To maintain motivation, the student should make progress toward recognized and meaningful goals during each ATD training session, and at least part of the progress must be apparent to him. Thus, the careful use of feedback to aid skill acquisition will itself lead to motivation to perform correctly. In addition, positive feedback expressed as approval from peers and superiors is generally helpful in maintaining maximum effort and favorable attitudes toward training. (For a further discussion of the effects of feedback on attitude and motivation, see Chapter VII.)

The second role of feedback, to inform the student as to the appropriateness of his cue interpretations and actions, is essential to the learning of skills. For example, a student learning to maintain a 2-1/2 degree glideslope on a visual approach for landing initially will be unable to discriminate the visual glideslope cues. If he receives no information regarding the accuracy of his descent angle, his performance is not likely to improve. On the other hand, if he is told when his descent is incorrect and the direction and the amount of his error, his performance will improve steadily.

Intrinsic Feedback

There are two kinds of feedback: intrinsic and supplemental. Intrinsic feedback refers to information that occurs naturally as a result of, or is inherent in, the performance itself. Almost all situations involved in aircrew performance contain a variety of inherent information. The reaction of an aircraft or ATD to the movement of a control stick provides intrinsic feedback, as do changes in cockpit instruments, aircraft noise, indications of weapons impact, etc. By observing such inherent indicators, a pilot's actions can be adjusted and "tuned." Operational skill will be determined by the extent to which an aircrewman can discriminate intrinsic cues in order to obtain the feedback needed for his continued control inputs.

All ATDs provide intrinsic feedback. Any ATD feature designed to provide the same cues that are provided in the aircraft when the same control input is made to each will provide intrinsic feedback. The greater the degree of physical similarity between the device and the aircraft simulated, the more appropriate intrinsic feedback it provides.

Early in training, students are not able to discriminate many of the cues that provide intrinsic feedback, either missing them entirely, misinterpreting them, or being unable to glean the required information from them. For example, students may be unable to discriminate the specific engine sounds that provide feedback to experienced pilots concerning power settings and rates of change. Eventually, the student must use such feedback and must learn to respond to it appropriately.

Until he learns of its existence and meaning, however, it is of no value to him.

One way to aid a student in learning to depend on intrinsic feedback is to augment it in some manner. Augmented feedback is intrinsic feedback that has been altered in such a way that its characteristics can be more easily discriminated by a student. For example, freezing a simulator at a critical point in a maneuver provides an opportunity to examine cue patterns that he must learn to recognize rapidly. A replay of a recorded maneuver in slow time permits greater opportunity for the student to note changes in instruments, instrument patterns, and simulated motion and visual feedback cues. Or, repetitive replay of particular segments of a recorded maneuver makes possible numerous exposures to feedback cues that occurred only once while the maneuver was actually being performed.

Supplemental Feedback

Teaching a student to discriminate intrinsic feedback cues often requires additional, immediately obvious, forms of feedback that are not themselves inherent in operational performance. The earlier example of an instructor providing error information to guide a student learning to follow a glideslope during a landing illustrates a common usage of such additional feedback. Initially the student would not be able to discern the intrinsic cues that could tell him when he had a correct rate of descent and angle of attack, so the instructor provides the information himself. Information of this sort is usually termed "supplemental feedback," that is, it is feedback provided to supplement the information available from intrinsic feedback.

An important function of supplemental feedback in skill acquisition is to inform the student of the availability and relevance of intrinsic feedback that he should look for and learn to interpret. For example, instructors often call out to students practicing an approach to a tanker the distances they are from the tanker while closing upon it. Knowing that he is 500 feet, then 300 feet, 50 feet, etc., identifies points at which visual cues can be discriminated. At each point, the student should be shown the cue characteristics that he can associate with the distances called out by the instructor. When he has learned these cue-distance associations, the instructor's verbal feedback (supplemental) will no longer be needed. The visual cues themselves will provide the feedback (intrinsic) needed to perform the tanker approach. Thus, supplemental feedback is most important early in training before a student learns to discriminate cues that provide intrinsic feedback.

Supplemental feedback is also useful as an aid in teaching response discriminations. While skilled operational performance depends on intrinsic feedback, it is not necessary to wait until the student is able to rely on intrinsic feedback before relevant responses can be practiced. While the student is hearing the instructor call out "300 feet," "100 feet," etc. as he closes on a tanker, he is receiving feedback regarding

the effects of his control inputs and can learn to adjust closure rates while simultaneously learning to interpret distance cues. Similarly, in a dive bombing run, instructor comments concerning the rate of pipper closure or the steepness of the dive tell a student whether or not his control inputs are adequate. Adjustments necessary to correct dive angles can thus be discriminated while learning to interpret the intrinsic cues that signal needed adjustments.

In such situations, supplementary feedback is necessary to aid the student in learning to discriminate cue meanings and control inputs. A student cannot learn to recognize a subtle cue or select and fine-tune a response unless subtle variations in cues and responses make a meaningful difference to him. While learning, a difference is often apparent to the student only through his instructor's comments, direction, or evaluation of his performance. The instructor must tell him that a pitch angle or rate of closure is correct or incorrect, and provide other information that defines conditions the student has not yet learned to recognize. Such supplemental feedback informs the student that what he is experiencing should be interpreted in terms of the information provided by the instructor. With practice, the ability of the student to recognize and respond to intrinsic feedback will increase to the point that he can depend on his own recognition of cue information, rather than on supplemental feedback supplied by an instructor.

Supplemental feedback can be given freely in ATDs, either under computer control (e.g., via automatically initiated aural alerts when performance envelopes are exceeded) or by the instructor. In addition, supplemental feedback can be administered through use of the device's various instructional features (e.g., freeze and record/playback) when, in the judgment of the instructor, it can be most effective.

Possibilities for feedback can be numerous even in ATDs without sophisticated instructional features. Many part-task trainers have relatively simple computer controlled or manually operated mechanisms for feedback. Even a paperboard mock-up to teach cockpit procedures can be an effective ATD, provided only that the student can tell the difference between an action successfully completed and one that is not. In many cases, all he would need for feedback is the ability to recognize himself whether or not he pressed a button, set a switch, etc. From the standpoint of effectiveness, it is necessary only that a sufficient context of meaning be provided so that whatever feedback is presented can guide or confirm the learner's discriminations and resulting actions.

Timing of Feedback

The timing of feedback represents a major area of concern to aircrew instructors. Several instructors indicated the belief that "immediate" feedback during training is necessary, but expressed difficulty in providing it. Further, they recognized the value of post-training period debriefing sessions, but were concerned that delaying feedback until such sessions was ill advised because of the need for rapid, even immediate, feedback.

Such concerns can be resolved by a simple principle: Feedback at any time can be effective so long as it can be meaningfully related to the specific cue and response discriminations of concern. Sometimes feedback must be immediate. For example, in the earlier illustration of an instructor calling out distances as a student learns to close on a tanker, it is important that the feedback "300 feet" be pronounced at the time the student's aircraft is approximately 300 feet from the tanker. If this is not the case, the stimuli the student experiences at 300 feet could not readily be associated with a known distance.

Furthermore, when feedback is needed for the timely initiation of a subsequent response, the response necessarily cannot begin until the feedback occurs. For example, when learning a coordinated skill sequence such as connecting with a tanker to begin refueling, the effects of one movement are often the cue for immediately initiating the next, and no observable feedback delay may be tolerable. Likewise, control movements requiring nearly instantaneous compensating adjustments, such as operation of flight controls during formation flight, must have immediate feedback. Otherwise, the pilot would be unable to make the adjustments soon enough for the task to continue, let alone for learning to take place.

On the other hand, delaying feedback for hours may not have noticeably disruptive effects on learning some tasks. For example, a pilot's navigation skills can be sharpened when he deviates from the intended course during practice, and discovers only after considerable time that he is not where he intended to be. For learning to take place in spite of the greatly delayed knowledge that he erred, it is necessary only that the pilot remember when his errors occurred and what they were.

When the relationships between cues and responses can be clearly remembered, delay of feedback is not a serious problem. For example, an instructor's statement during a post-ATD debriefing, "You were slow in adjusting your airspeed," can be effective feedback if the pilot can remember the sequence of cues leading to the ones he used during practice. Summaries of performance and records of events occurring during training, such as are provided by hardcopy printouts of instructor station displays, for example, aid the student in remembering just what happened at a particular time and offer excellent data for feedback during debriefings.

If there is reason to believe that pertinent cues and responses may not be clearly recalled after the session, feedback should be provided sooner. Instruction in ATDs can be more effective when prompt feedback is required than can instruction in an airplane. The instructor can freeze an ATD whenever it is appropriate to do so to provide feedback. Promptness of feedback can be especially important if the bases for the errors, i.e., misinterpretations of cues and/or erroneous responses, are likely to become vague with time.

Problems of Overuse and Underuse of Supplemental Feedback

Supplemental feedback poses special difficulties. If used too freely, a student may learn to depend on it rather than learn to discriminate the feedback cues that are a natural part of (intrinsic to) the task being learned. When supplementary feedback substitutes for intrinsic feedback, the student learns to key on supplemental feedback. Therefore, supplemental feedback should be used only to direct attention toward intrinsic feedback. To ensure that this is happening, supplemental feedback should eventually be withdrawn so that the student can practice depending on himself. He should be forced to seek and interpret intrinsic cues.

Generally, this means that supplemental feedback is valuable primarily in the early stages of learning to make the cue and response discriminations necessary to a particular task. As learning progresses, it should be withdrawn. Even early in learning, the student should sometimes be required to practice without supplemental feedback as a way of determining whether it is still needed.

Students vary in the extent supplementary feedback is needed. A rule of thumb for its use is available to the instructor, however: Because it is needed primarily to direct attention to cue and response discriminations, it is not needed to the extent these discriminations are being learned without it. Therefore, if skill learning is progressing steadily, withhold supplemental feedback; if not, provide it for a while, then withhold it and check progress again.

Too little use of supplemental feedback was found to be more of a problem during ATD training than was overuse. For example, some IPs withhold most comments regarding student performance until a post-flight debriefing. In one instance in which a student was practicing in an ATD while transitioning to a single-seat fighter, an IP commented that because the student would have to depend on himself in the aircraft, he should do so in the ATD; therefore he should not be given supplemental feedback in the device--an extreme case of underuse.

A widely noted misconception seemed to underlie training practices of this sort. It is that task fidelity and situational realism must be maintained during all aspects of training. Certainly, these aspects of the training situations are important, particularly during advanced stages of ATD training and when practicing operational tasks in aircraft. However, the training conditions such beliefs foster are incompatible with the use of supplemental feedback when it is needed to direct the student's attention to cues essential to skill performance. The implication of training practices based on such beliefs is that a novice can teach himself what cues to attend to and how to respond to them as efficiently as an expert instructor can. The implication is unsupported with respect to aircrew training.

GUIDANCE

Guidance is the directing of actions of a learner toward a desired goal. The actions being guided may be thought processes, physical movements, oral communications, the selection of cues, or the processing of cue information. Guidance is involved every time an instructor comments to a student about what he should do, remember, or think about.

Properly used, guidance helps in the learning of aircrew skills in two ways. First, it speeds learning when it identifies desirable cues and responses that the student cannot recognize on his own. Second, by identifying correct cues and responses, it reduces the likelihood that inappropriate cues will be used and incorrect responses made. Thus, it helps prevent learning of erroneous actions that would eventually have to be unlearned.

Guidance in Early Training

Guidance is especially important in early training. A novice aircrewman is confronted with many new potential cues. Some are not even noticed at first, and the meanings of many others are only vaguely perceived. Furthermore, the responses that should be made to particular cues are largely unknown to a novice, and those that are known frequently cannot be coordinated with their cues. Through guidance, students can be led to focus upon correct cues, their interpretation, and the types of responses they require.

The most common forms of guidance in aircrew training are written and oral instructions. These are the principle forms that have been available for use throughout most of the history of aviation. However, current state-of-the-art ATDs offer capabilities for guidance that can be superior to words for some instruction. For example, in an ATD with a capability for automated demonstrations, many cues and responses that the student must learn to discriminate but that are difficult to describe verbally can be observed and even experienced by the student. An automated demonstration can illustrate precisely (within the fidelity limits of the device) what the student must learn to do. If the demonstration also includes movements of the ATD's controls, by keeping his hands and feet on the controls the student can be guided both in types and magnitudes of responses he will be required to learn. Furthermore, an ATD instructor, freed from responsibilities for maintaining safe flight as he must in an aircraft, can supplement the programmed guidance provided by the automated demonstration through verbal directions regarding the cues to notice, how to interpret them, and how to respond when they appear. If the ATD design permits the demonstration to be played at slow speed and/or selected segments to be repeated, the instructor can use these capabilities to focus on cue-response coordinations that are particularly troublesome to discriminate in real time.

Many devices do not have instructional features that permit demonstrations to be presented automatically. In some such devices, an instructor can demonstrate required performance manually, either by operating flight controls located at the instructor station or by occupying a copilot position in the device itself. Even in devices with automated demonstration, instructors may wish to use these manual control features to demonstrate something not included in available automated demonstrations. (A similar capability exists for instructor-conducted demonstrations in aircraft with dual controls, of course, and is widely used during in-flight training.)

Although not commonly used in ATDs, demonstrations of inappropriate actions can have a positive guiding value if they are used to highlight appropriate actions. Some flight instructors recognize this point intuitively. For example, they may say, "Here's the way some students try to do it; now notice where they go wrong." This well-founded intuitive approach to teaching discriminations is frequently used in flight to highlight correct actions. It could also be used in some ATDs (e.g., those configured to permit an instructor to occupy a copilot's position) that do not have an automated demonstration capability. Inappropriate performance could also be demonstrated automatically in devices with that instructional feature, although no examples of such uses were found during the current project. It is important, of course, that any demonstrated inappropriate performance be clearly identified as such, and that its purpose be to aid the discrimination of correct actions.

Replay of a student's errors can accomplish a similar guidance purpose, but such replays must await an incorrect performance that in many instances could and should have been prevented. Replay has the advantage, however, of focusing on each student's particular problems and thus combining guidance with feedback for more effective training. While a student is guided during replay to discriminate correct cues and responses he can also observe the effects (i.e., receive feedback) of his earlier judgments and control responses.

References to combining guidance and feedback have sometimes been confusing to ATD instructors, especially when feedback seems itself to have a guiding role. "Guidance" usually refers to direction given a student before he attempts a learning task. "Feedback" is information regarding the adequacy of his performance after he does the task. Generally, feedback can be used to guide future performance, and when it is, new attempts at correct performance should be made while the correct cues and responses are still vivid in memory.

Combined use of guidance and feedback can be easily accomplished in an ATD with freeze and "fly out" capabilities associated with the Record/Playback instructional features. For example, suppose a student overshoots a 180° turn because he starts the rollout too late. During replay of a recording of the maneuver, the instructor could identify the progression of cues, freeze the device at the point rollout should have

begun, and let the student "fly" it out. The student thus gets feedback quickly on what he did correctly, has the important cues for initiating the turn pointed out, and receives verbal guidance from the instructor for correcting his mistake. By "flying out," he has an opportunity to correct the mistake while the cues and responses are still freshly in mind.

This is not to say that all feedback used as guidance must be given immediately after an action. It is necessary only that the information received by the student meaningfully directs him regarding actions to pursue or avoid. As explained in the earlier discussion of feedback, the essential point is that the cue interpretation and/or response at issue be clearly remembered. Even during debriefing, feedback can have a positive guiding effect if the student can "relive" the experience in his memory, i.e., recall the cues and responses clearly while discussing the adequate and inadequate aspects of his performance with an aircrewman peer or with an instructor.

Guidance can be particularly useful in ATDs of relatively poor fidelity. Whether cue and response discriminations learned in such ATDs can be generalized to a target aircraft depends on whether the student has focused upon those that are common to both the device and the aircraft, and has learned to ignore aspects of ATD cues and responses that do not appear in the aircraft. For example, changes in apparent runway shape, varying look-down angles due to deviations in height, increasing apparent speed relative to the ground while descending, etc., are visual cues common to all landings. Such cues can be represented in many simulated visual scenes, even though the scenes themselves might be of low fidelity and appear unrealistic (e.g., symbolic or "cartoonish"). An instructor can guide a student to focus on the perspective, blocking, movement, and other cues that are common to the simulated scene and the "real world" scene and to ignore image distortions, color aberrations, or other features of the scene that are unique to the simulation.

The effectiveness of such instruction will depend, of course, upon the ability of the student to utilize similar cues in flight. With sufficient aircraft experience, and with guidance to notice similar cues while flying, the generalization of appropriate ATD visual cues can be enhanced, and the danger of restricting cue recognition to device-peculiar characteristics can be minimized. The student must not be permitted to use device-peculiar characteristics to achieve good performance in the device at the expense of subsequent performance in flight.

Guidance in Advanced Training

As an aircrewman's career progresses, he is continually trying to acquire new, more advanced skills and hone previously learned ones. Each time a pilot transitions to a new aircraft, e.g., from a T-37 to a T-38, and later to a bomber, tanker, cargo aircraft, or fighter, he is in many respects at an "early" stage of learning new skills. He needs guidance

to help identify key cue characteristics and response requirements for the new aircraft. In addition, past experiences in other aircraft will have provided many well mastered cue and response discriminations that can be built upon in acquiring the new skills. In such situations, the experienced learner should be guided to select previous discriminations that generalize readily to the new tasks. He should also be made aware of past habits that must be altered or avoided when flying the new aircraft.

For example, instructors often emphasize to students that they should focus on instruments when transitioning to a new aircraft such as the F-4. The students already know how to interpret F-4 instrument cues because they are essentially the same as those used in other aircraft they have flown. By being guided to use them, and, in turn, using them to help interpret new F-4 cues, instructors report that the "feel" of the new plane can be learned by students more quickly.

The need for guidance in aircrew training does not end when skills have been learned. Guidance is also needed to maintain previously acquired skills, or to re-establish levels of skills that may have deteriorated during periods of infrequent practice. The most commonly noted example of the use of guidance not involving new skills was the scheduling of flights with instrument flight instructors a day or two before taking periodic instrument flight checks. These flights provided opportunities for coaching (i.e., guidance) where deficiencies might be detected in order to assure passage of the subsequent check. Such activities are taking place in both aircraft and ATDs.

Guidance during advanced training in modern ATDs is not necessarily dependent upon an instructor. The automated voice message guidance capabilities of several devices, e.g., automatic alerts when performance parameters are exceeded and instructions and commentary accompanying automatic demonstrations, were found to be valued by some experienced pilots who were practicing previously mastered skills when qualified instructors were not present. In some instances, these pilots simply had forgotten or were unable to meet exact performance standards. Or, they had forgotten how to initiate a maneuver, or how to coordinate aircraft dynamics with vectors required for weapons delivery. Some experienced aircrewmembers found that automated demonstrations of task performance aided them by defining standards in performance terms, i.e., not only identifying them but showing how they are achieved. Automated demonstrations can also help prevent unproductive trial-and-error efforts during reacquisition of partially forgotten skills, thus speeding relearning.

Precautions in the Use of Guidance

Guidance can easily be overdone. A student can learn to depend on external guidance such as verbal directions from an instructor rather than depending on himself. While guiding information may be needed to

facilitate skill acquisition and maintenance, operational performance must not depend upon its presence.

The most common instances of overuse of guidance in ATD training identified during this study were by instructors who were overprotective. That is, they tried to prevent students from making mistakes by giving too many instructions too often, by dominating the controls, or by taking over controls ("stick grabbing") when students deviated only slightly from requirements. It is sometimes important that students be permitted to make mistakes. Learning to discriminate between a correct action and a highly similar but incorrect action can be facilitated if the student can experience both, and identify their differences.

Guidance should be used only when needed to focus on cue and response discriminations that the student is not yet able to make unaided. A simple rule of thumb is available for the use of guidance: Withhold guidance and note whether the student progresses in performance. If so, let him work on his own until progress ceases.

This rule is easy to follow in an ATD, but often more extensive guidance must be used in aircraft to assure continued safe conduct of the flight. Some combat maneuvers are too dangerous to allow students to attempt if they are likely to make dangerous errors: An A-7 should not be put into a departure condition by an unprepared student; an F-4 should not be stalled at all. Opportunities to recognize cues that lead to stalls thus must be limited in the A-7 and F-4 aircraft, and responses required for precision performance of dangerous maneuvers must be carefully guided. In ATDs, approaches to stalls could proceed to intolerable limits, and a student could experience when he has exceeded "safe" performance cues. He can learn how not to execute a maneuver as well as how it should be flown. Safe performance in aircraft would then be more likely, because cues indicating danger could be more reliably discriminated by the pilot.

SUMMARY

This chapter discussed three factors of critical importance in aircrew training. First, the role of cognitive training was explained, including the use of cognitive processes in developing knowledge of aircrew tasks and in aiding skill acquisition. Second, the need for aircrew students to obtain information, i.e., feedback, regarding their actions, and productive and nonproductive uses of feedback, were described. Third, the role and effective use of guidance in ATD training were addressed, as well as the dangers of overuse of guidance. These discussions are summarized below.

- A meaningful context should be provided for the learning of skilled performance in the ATD. In recognition of the role of mediation in the acquisition of aircrew skills, the student should be given information that will enable him to interpret stimuli, process cue

information, and select appropriate responses. He should be informed of the purposes of actions, their context, and types of decisions to be made regarding those actions.

- Mediation should be employed systematically in teaching cue and response discriminations. The student should be guided as to what he is to think about during the performance of a task. He should be made conscious of what he is experiencing so as to make cue and response characteristics stand out. For full effectiveness, various auditory explanations and representations should be coordinated with verbal presentations.

- Students, when they are practicing in the ATD, should be instructed to think about the meaning and effects of their actions with respect to requirements for performance in the aircraft. ATD practice should be in a context of realism regardless of the physical characteristics of the device. Awareness of such provides a basis for transferring discriminations of cues and responses to aircraft performance.

- Briefing for ATD sessions should anticipate and guard against a student's relating what he does during ATD practice only to the ATD itself. Over and above explanations of performance requirements, the student should be prepared through briefings to imagine the occurrence of cues missing in the ATD, to focus on those aspects of cues present in the ATD that also appear in actual flight, and to ignore aspects not available in flight.

- Recognizing that transfer is a mediational process, a major goal in ATD training should be to exploit the types and uses of mediation that maximize transfer. Since ATD-aircraft cues and responses are not identical, it is important that cues common to both ATDs and aircraft be discriminated from those that are unique to the ATD. Similarly, the usable components of ATD responses associated with the common cue meanings must be discriminated from those that are specific to the ATD. Both of these types of discriminations result in transfer, and cognitive mediation is an essential means of learning to make them.

- Feedback determines the nature and extent of discriminations that will be learned. Uses of feedback should be designed to ensure discriminations of task-intrinsic cues, their interpretation, and the appropriate actions necessary for skill performance.

- Feedback should focus on specific aspects of cognitive, perceptual, and motor actions that must be discriminated. Generally the learning of subtle characteristics of actions depends on the occurrence of feedback directed toward the specific characteristics that are to be discriminated.

- Augmented and supplemental feedback should be used only when task-intrinsic feedback cannot be discriminated, and its use should be

specifically for the purpose of teaching cue and response discriminations intrinsic to the aircraft task. The need for such feedback is determined by the student's ability to discriminate and use intrinsic feedback. It should not be continued to the point that the student becomes dependent on feedback that will not occur in aircraft.

- Timely supplemental or augmented feedback should be used to signal the availability of intrinsic feedback. By associating stimulus conditions with information provided through supplemental and augmented feedback, the cue information in the stimuli can be learned.

- The timing of augmented and supplemental feedback should be determined by requirements for learning discriminations of task-intrinsic cues and actions. How soon such feedback should be provided after a cue interpretation, judgment, or motor response depends upon how long all pertinent characteristics of the action can be vividly remembered.

- When intrinsic feedback is needed as a signal for a subsequent action, ATDs must provide it quickly enough to avoid disrupting the action. Coordinations of control movements with many motion, visual, and instrument cues require immediate feedback if the movements are to be smooth and their component responses timed accurately.

- Feedback will help maintain student motivation if it ensures progress. Learner satisfaction depends on progress. When the student is unable to perceive that progress has been made, supplemental feedback, such as favorable comments by the instructor, should be used.

- The purpose of guidance is to focus the student's attention on correct cue and response discrimination and to avoid incorrect cue interpretations and actions. Guidance speeds up learning when it prevents irrelevant efforts by the student and focuses his attention on pertinent cues, their meanings, and indicated actions.

- To avoid a dependence on guidance, it should not be used when the student is able to make the required discrimination without help. The goal is to teach self-sufficiency in task performance. Therefore, the student should practice as much as possible selecting his own cues, determining their meanings, and selecting appropriate actions. A rule of thumb for employing guidance is to use it only when the student cannot discriminate appropriate cues and responses as indicated by an unsatisfactory rate of progress when left on his own.

- Contrasting, through guidance, desirable with undesirable cue interpretations and responses can highlight critical cues and responses when the discriminations to be learned are difficult. The emphasis should be on desirable aspects of actions, with undesirable aspects clearly identified as such and used only when contrast is needed.

- When feedback is used primarily in a guiding role, it should occur as soon as practical after the action, and the student should

repeat the action without undue delay. To guide an action in retrospect, the cues and components of the action must be vivid in memory when the feedback is given, and correct performance should be attempted while it is freshly in mind. A novice may need immediate feedback followed by additional efforts; but for an advanced student, delayed feedback even during a debriefing can have a guiding function if its relation to cues and responses is clear and remains so for subsequent trials.

- Guidance should be used during advanced training when needed to focus students' attention on new cue and response discriminations, or on previously mastered discriminations that can be generalized to new tasks. Transition training especially involves new variations of familiar cues and responses. Similarities to previous cues and responses as well as differences should be pointed out.

- Guidance can be valuable for experienced aircrews when the skills have deteriorated appreciably, or when it can define or clarify standards for performance. Once a skill has been mastered, an aircrewman will usually have the discriminative capacity to profit from ATD practice without external guidance. However, if cue and response discriminations have deteriorated seriously, some guidance may be beneficial. Also, some experienced and fairly proficient aircrews have found programmed demonstrations valuable because they illustrate the standards for ideal performances.

- Guidance should focus on aspects of ATD skill performance that are transferable to aircraft, or can promote transfer. These aspects may be cues and responses per se, or generalizable aspects of them. In process, students should be guided to notice ATD-specific aspects of cues and responses so they can be discriminated and negative transfer avoided.

CHAPTER V

CONSIDERATIONS IN STRUCTURING ATD TRAINING

The two preceding chapters described the learning process as it relates to ATD utilization (Chapter III) and the conduct of ATD training (Chapter IV). The present chapter addresses factors to be considered in the structuring of ATD training. These factors are: (1) establishing priorities for ATD uses; (2) sequencing ATD training in relation to academic and flight training; (3) allocating training among various types of available ATDs; (4) organizing tasks into practice sessions; and (5) determining the frequency and duration of individual ATD training sessions.

PRIORITIES FOR ATD SCHEDULING

In addition to introducing aircrews to operational performance requirements at both UPT and combat crew training levels, ATDs have been used for continuation and refresher training, for upgrading and teaching special skills, and for remedial training. At some locations they are being used in training aircraft maintenance personnel, loadmasters, traffic controllers, ATD instructors, command personnel, and even flight surgeons.

Scheduling ATDs for training thus needs to be responsive to two types of priorities. One type involves different kinds of training, (e.g., combat crew training vs continuation training vs instructor training vs maintenance personnel training). The second involves different training needs within a training group (e.g., aircraft control vs emergency procedures vs low level navigation).

Both types of priorities are concerned with assuring that the ATD is utilized appropriately during routine use as well as when its availability changes. Such changes may occur when scheduled or unscheduled device maintenance must be performed during time periods normally used for training, or when fluctuations in the flow of students through the training pipeline make increased or decreased demands on ATDs and other training resources. These and other such events can necessitate the reallocation of training activities normally scheduled for ATDs to other resources, or can make the devices available for training normally conducted by other means. If periods of increased device availability can be anticipated, training groups that could benefit from ATD training can be identified and training scheduled for them to take up the slack. Likewise, in times of high demand by top priority groups, alternative, less efficient resources could be used by those lower in priority.

It is desirable to establish priorities for training tasks on the basis of the kinds of training that can be done best in each available

device. Alternative resources, including aircraft, should be identified for each task to be trained, and the relative effectiveness and efficiency of each resource estimated. Trade-offs could then be made between priorities and alternative ATDs, with cost helping to determine the trade-offs. ATDs could be scheduled so as to be available for various training activities and groups according to an optimum priority grouping of tasks, with media alternatives and costs taken into consideration. Such systematic planning for the use of ATD resources was not found to have taken place at any of the units surveyed during the present project.

It is important to establish priorities for use of ATDs before the need for use of alternative resources arises. Course syllabi should reflect such priorities by identifying alternative training resources to be considered for use. With adequate forewarning, instructors could be trained to deal with the contingencies governing uses of ATDs as their availability varies and be prepared to use these devices and other resources as necessary.

Fixed procedures are not available for making these trade-offs and developing alternative schedules. The general guidance contained in the section of this chapter dealing with the allocation of training to ATDs will be useful in making the trade-offs, as will the discussion in the section dealing with the separation of tasks for practice. In addition to this guidance, the trade-offs must be based upon the experience of training personnel with the devices and training requirements involved.

SEQUENCING ATD AND OTHER TRAINING

The contributions of ATD training varies depending upon how it is integrated with aircraft and academic training. Four considerations are of concern: (1) Training in ATDs can provide concrete meaning for theoretical knowledge and timely practice in applying that knowledge; (2) academic instruction can sometimes be more meaningful if it follows ATD practice; (3) transfer of ATD training to aircraft often requires practice in aircraft soon after ATD learning; and, (4) some ATD instruction will be more meaningful if it is preceded by exposure to the tasks in aircraft.

Application of Theoretical Knowledge

Since the purpose of most academic training is to convey information (knowledge) necessary to the development of skills in ATDs or aircraft, it is appropriate that it usually be scheduled to occur before those skills are first practiced in the device or aircraft. That is, ATDs normally should provide practice in use of knowledge and theoretical concepts presented during academic training after the concepts have been learned at a verbal level. The ATD scheduling question is how long after academic training will such practice be most fruitful?

The answer must be in terms of the retention capabilities of students. Factors to consider in retention are the vagueness of distinctions among tasks when they are understood only verbally; the length of time the student can remember whatever discriminations he has learned; and, since tasks currently being practiced but not yet mastered can interfere with new learning, the amount of new information that can be presented during academic instruction prior to ATD practice without loss of efficiency.

There are no simple rules to follow in considering these factors. Decisions in a particular training program must be based upon the judgment of personnel familiar with the training being conducted and the experience levels of the students involved. The counsel of experienced instructors and educational specialists obviously can be helpful in making such judgments.

A point to remember when making decisions is that opportunities to apply knowledge acquired during academic training should not be delayed for very long for novices. They will not have sufficient prior mastery of related knowledge to prevent concepts from getting mixed up. As the related experiences of the student increases, however, greater delays can be tolerated without ill effects. Thus, the experience level of the student is a factor in scheduling ATD practice, with the less experienced student needing practice sooner after relevant knowledge has been presented to him.

ATD Training First

The second consideration concerns the need for ATD experience prior to academic training. There are situations in which prior experience or familiarity with an application of theoretical concepts will make it easier to understand the knowledge to be learned. Dive angles required for specific weapons delivery tasks, for example, cannot be meaningful verbally until after the student has had some experience with the visual images and kinesthetic feedback that accompanies performance of these tasks. The point is that concrete anchors for knowledge should be provided when they are needed; and for some academic instruction to have meaning, it is necessary that the student at least have limited experience with the actual cues and intrinsic feedback associated with the tasks concerned.

When ATDs can provide the experiences, specific ATD practice should be scheduled prior to or concurrent with academic exposure to the knowledge of concern. For example, ground effects can be explained, but the student will probably still be somewhat startled the first time he experiences them. Experience with ground effects, their onset and disappearance, will enable the student in his imagination to integrate control adjustments with conditions under which they occur.

Integrating ATD and Aircraft Practice

The third consideration that has implications for scheduling concerns the interspersing of ATD and aircraft practice. Training conducted in ATDs must involve some symbolic cues and responses, because the fidelity of all current state-of-the-art devices is less than perfect. For lower fidelity devices, a large proportion of the cues and actions required for performance of operational tasks are often symbolic. (Reliance upon symbolic cues and responses when using ATDs is discussed extensively in Chapters III and IV.)

Just as ATDs can provide concrete anchors for understanding academic or theoretical concepts, timely aircraft practice can provide the actual cues and responses needed to anchor ATD-based symbolic knowledge in operational reality. Considerations involved in the timing of such practice in aircraft are similar to those described above for the practice in ATDs of knowledge and theoretical concepts learned during academic instruction. That is, the delay should not exceed the retention capabilities of the students. The more symbolic the training conducted in the ATD, the shorter the delay should be. Likewise, the less experienced the students, the shorter the delay should be. Thus, relatively inexperienced students undergoing training in relatively low fidelity devices should be provided opportunities to employ the ATD-developed skills in the aircraft as soon as practical. As student experience levels increase and higher fidelity part-task trainers and simulators are employed for skill acquisition, longer delays can be tolerated without unacceptable decrements in performance. In any event, delays should be no longer than necessary to accommodate the practical aspects of scheduling all training activities.

Aircraft Training First

The fourth consideration concerns the fact that for some tasks, aircraft experiences may be needed before ATD practice so that the latter can have the meaning necessary for effective training. Part of the discussion in a later section of this chapter on allocating training among ATDs is especially pertinent here. It is explained there why an experienced aircrewman can derive more training benefits from a low fidelity device than a novice can. Basically, the reason is that the symbolic actions required to perform some tasks in some ATDs already have concrete meanings for the experienced aircrewman because he "has been there before." Therefore, the more novel the task to be learned in the ATD--the purpose, the cues, the actions--and the lower the ATD fidelity, the greater the need for aircraft experience prior to ATD practice. Perceived altitude at roundout, for example, is vague at best to one who is not familiar with ground cues for height; "feel" cues characteristic of a float are foreign to one who has never flown an aircraft in this situation; control corrections to counteract torque or adverse yaw are just textbook instructions until the feel of maintaining corrections becomes associated with actual perceptions of their effect on the

behavior of an aircraft. Schedules should permit tasks involving unfamiliar cues and responses to be attempted or demonstrated in aircraft before the tasks are practiced in ATDs.

The importance was noted in Chapter IV of pointing out to students any discrepancies between ATDs and aircraft during training in the devices. However, these differences may not be understood when an instructor describes them. Again, this is more likely to happen with inexperienced students than with more experienced ones. To discriminate differences in his imagination, he must be able to experience the differences in his imagination. If past experience is not sufficient to define the differences for him, and if the experience can be obtained only in an aircraft, he will need some aircraft experience either before or interspersed with ATD training. The "dollar ride" given at the beginning of some aircrew training programs, if carefully structured, can provide such experience.

ALLOCATION OF TRAINING AMONG ATDS

ATDs can vary in effectiveness and/or efficiency for teaching a particular skill. In such cases, a plan for the use of specific ATDs should reflect the capabilities of individual devices. In addition, occasions arise when two or more different types of ATDs are available and are essentially equivalent in value for teaching a particular skill. If so, factors other than device capabilities can be considered in their use. The purpose of this section is to examine these two aspects of ATD utilization.

Utilization Based on ATD Capabilities

One consideration in ATD utilization is the extent to which verbal instruction or other symbolic cues and responses can substitute for or supplement cue and response fidelity in a particular device. A second consideration is the prior experience of the student. A third is the amount of practice required to master the skill or skill segment of interest. A fourth is the generalizability of the skills being practiced.

Substitution of Cues and Responses

This consideration is primarily concerned with needs for physical fidelity in ATDs. Strict fidelity is not required if appropriate cues and responses can be visualized by the student. For example, low physical fidelity devices can be used to teach many procedural tasks, because students can vividly imagine the events that make up the procedures, e.g., using a radio, sighting a target, positioning a control, observing the status of a light, and determining the value indicated on a meter or display. Similarly, students can comprehend the actions that would affect these events without actually having to engage in them, and they

can imagine the consequences of those actions (i.e., feedback) without its actually occurring.

As one moves from procedural tasks to aircraft control type tasks, however, students will not as readily be able to imagine the feel, pressures, and other types of intrinsic feedback that their actions normally provide, so the device generally must be of higher fidelity. That is, the students must be able to engage physically in the action involved in performing a task, and the feedback critical to accurate performance of those tasks must be provided.

Prior Experience

In allocating training to ATDs that vary in fidelity, the experience of the student must be taken into consideration. As a general rule, the more experienced the student in interpreting cues and responding to them, the more he can employ imagery during his training and the less dependent he is upon device fidelity in learning a particular skill. An experienced pilot can derive more training value from a low fidelity device than can a novice because he can, in his imagination, more readily "see" an instrument change, "hear" an engine start, "feel" an acceleration, etc.

It does not follow, however, that high fidelity is not desirable or needed when the students are experienced aircrewmembers. High fidelity simulation is viewed by most pilots as increasingly important as their proficiency and experience levels increase because the skills to be practiced require coordination of cue-response systems where realistic kinesthetic and visual feedback must be precisely integrated. Such is the case in continuation training and maintenance of operational proficiency, and the device selected for these purposes must provide realistic control dynamics and task-intrinsic feedback regardless of prior learner experiences.

Practice Requirements

In allocating training to various part-task ATDs, portions of tasks that are commonly difficult to learn should receive specific attention, and ATDs should be sought in which additional practice on those tasks can be provided without requiring that time be spent on skill components already mastered. For example, vectoring for an aerial intercept is relatively difficult for a student when the task is first introduced. However, he will not require much practice actually piloting the aircraft at such a point in his training, since he presumably already will be relatively proficient at that task. Extensive training on the intercept task itself can be conducted in a part-task trainer that permits practice of vectoring (e.g., an operational flight trainer), and when performance standards are met, the intercept skills can be integrated with previously existing aircraft control skills in a weapons systems trainer or other device that permits the complete task to be practiced.

An analysis of the learning tasks using the suggestions for task separation discussed in a later section of this chapter could identify a number of aircrew skills that could be practiced separately from other tasks. These different task elements and segments could then be allocated to different part-task ATDs in such a way that the overall capabilities of each type device could be used efficiently. Mission simulators and similar complex, "sophisticated" devices would then be used primarily for sophisticated purposes, i.e., to provide practice in integrating the various task parts into meaningful whole-task performance.

Generalizability of Skills

A major concern in ATD training is the generalizability of the skills being learned. Skill generalization depends upon having learned to discriminate key cues and responses. Provisions for cues and responses that are keys to performance of particular tasks should be a major basis for the utilization of ATDs. When one focuses upon the cues and responses that underlie performance of the tasks to be practiced, he then can select an ATD with those cue-response characteristics and allocate practice of such tasks to it.

The significance of the generalizability of skills training for the allocation of training to particular ATDs is illustrated in the use of a T-40 trainer for practice of instrument flight skills by B-52 and C-135 pilots. It did not matter so far as performance in the aircraft was concerned that the T-40 was radically different in cockpit configuration and dynamics from these pilots' operational aircraft. The cues and responses that are keys to the instrument flight task were present in these devices. Therefore, instrument flight training could be conducted for the pilots in the T-40 instrument flight trainer while other training was allocated to ATDs that simulated their operational aircraft.

This example also illustrates how aircrew skills that are not dependent upon a particular aircraft can be mastered independently of aircraft configuration, and, hence, in ATDs that do not necessarily correspond to a particular operational aircraft. Skills are learned in vehicles (ATDs and aircraft), but properly mastered, they become relatively independent of given vehicles. They become part of the skills inventory of the aircrewman who has learned them, and can then be used in a variety of vehicles.

ATDs not targeting specific aircraft were looked upon with disdain by many of the training personnel interviewed during the present project, as were low fidelity devices in general. They should not be. Clearly, the more tasks that can be performed in a device, the greater its potential training value. However, even devices in which only a few tasks can be performed can have training value for these tasks equal to the value of more complex devices. If generalizable cues and responses are involved, a skill learned in a low fidelity part-task trainer will be

just as valuable in the aircraft as will the same skill learned to the same standards in a high fidelity, full mission weapons system trainer.

Utilization of Equally Useful ATDs

There are situations in which ATDs of different levels of fidelity and complexity are available for use, and they are essentially equal with respect to the training to be conducted. In fact, such occasions arise frequently. For example, in most combat crew training units, both CRTs and DFIs are available and are essentially equally suitable with respect to the training of combat procedures tasks. In deciding which device to use, the criteria which would favor the utilization of available ATDs do not apply. There are other factors to consider, however.

One such factor, of course, is cost. Insofar as operational costs vary among devices, and device "wear and tear" is increased by use, capital and maintenance costs become important considerations. Cost was observed to be a major consideration in allocating training objectives among ATDs at most of the units surveyed during the present project. Cost is also specified as a major consideration in making such allocations in ISD and other training program development manuals, e.g., AFP 50-8.

It was the opinion of the project staff, however, that cost was sometimes weighted too heavily in decisions concerning the use of ATDs. Instances were noted in which pilots' preferences among available ATDs were ignored in order to use a relatively low cost device, even though a preferred but more costly device was available. The negative effect on attitudes toward ATD training resulting from this practice may well have outweighed any cost advantage realized.

While cost must be considered in any resource allocation decision, it should not be the only factor considered in utilizing ATDs. Consideration should also be given to the preference of the aircrewmembers who will be trained and of the instructors who will administer the training. The ATD preferred by these personnel, in most instances, is the highest fidelity and most nearly full-task device available. Low fidelity procedures trainers are usually least preferred, regardless of their demonstrated training value or lower operating cost.

It is important that user preference be given consideration. Particularly, situations should be avoided in which a less preferred device is required to be used, but an equally suitable preferred device remains unused. The influence of such ATD utilization on instructor and student attitudes toward training management was observed to be negative in several units where this situation was observed. (More will be said about ATD user attitudes in Chapter VII.)

ORGANIZING TASKS FOR PRACTICE

A consideration in the design and conduct of any ATD training activity is the need to organize the tasks to be learned into practice sessions. Whether motor skills, procedural skills, communications skills, etc., or more typically, a combination of skill types, are to be learned, two points stand out: (1) cue and response complexity should be reduced in early stages of the development of a skill; and (2) skills should eventually be practiced in situations representing the full complexity of operational performance. Two questions follow from these points: How should tasks be separated for practice so that their complexity can be reduced while learning the component tasks? How can training ensure the eventual integration of tasks learned separately? The subsections which follow address these questions.

Separating Tasks for Practice

Even the most routine tasks required in aircrew performance involve using information from many cues and making many responses. Landing, for example, consists of maintaining precise control of an aircraft during a series of sequentially dependent actions while simultaneously performing actions identified on a landing checklist, scanning the area for other aircraft, communicating via radio with controlling agencies, modifying flight according to information received in the communications, etc. An experienced pilot performs these tasks more or less mechanically. He does not have to think about each cue and response in order to perform it correctly. But to a novice, landing consists of many tasks involving cues and responses that are not yet under control well enough to be performed individually without error, let alone as part of a single larger task.

Often the most efficient way to learn complex tasks is to practice meaningful parts, or subtasks, in relative isolation from each other. Thus, parts of a complex task should be separated from others if they can be learned more easily when practiced separately. For example, radio communication can be learned more easily when separated from aircraft control during initial skill acquisition, and discriminations of features of a wingman's aircraft that will serve as positional cues during formation flight can be learned more easily when practiced separately from the task of scanning for other aircraft. Likewise, a task should be separated from others when such separation will facilitate cue discernment. For example, aural cues indicating engine malperformance might not be discernible when practiced together with other tasks having unusual sound cues.

Avoidance of inter-task interference during learning is not the only reason for separation of tasks, although it is probably the most important one. Other reasons for separating tasks for practice include the need to limit the length of practice sessions, the convenience of dealing with common subject matter at one time, and the availability of

ATDs in which only selected tasks can be trained (so-called "part-task" trainers).

There are rules of thumb that can be used for identifying tasks for separate practice. (1) Tasks requiring small amounts of practice should be separated from tasks requiring larger amounts. For example, landing requires more practice than taking off, so landing in an ATD can be isolated from the normal takeoff-landing sequence for concentrated practice. (2) Tasks that can be mastered more easily when practiced repeatedly should be separated from others. For example, aircraft control during formation flight can be separated from other mission activities; operation of EW equipment can be practiced separately from aircraft control. (3) Tasks with "natural" break points can be conveniently divided into separate segments for practice. For example, probe insertion provides a break point for dividing the task of aerial refueling into an approach segment and a station keeping segment.

A necessary condition in dividing tasks for separate practice is that any resultant task grouping make good sense! It must bear a relationship to overall mission performance that is clear to the student, or that can be made clear through explanations. Groupings that do not meet this condition, regardless of other criteria, could lead to development of "skills" of little value in the aircraft or that would be difficult to use in combination with other skills to achieve mission goals.

Integrating Tasks Learned Separately

Tasks learned separately must eventually be integrated into larger tasks involving longer sequences of actions or simultaneously occurring actions. Such integration will eventually occur simply if the larger task is practiced as a whole after the separate parts have been learned. The integration of separately learned tasks will be made easier, however, if provisions for their integration are made when the separate tasks are being practiced. Such provisions are described below.

Integrating Sequential Tasks

For separately learned tasks that normally occur successively in time, integrating tasks involves linking them to form components of a contiguous sequence of tasks. In such linked sequences, the ending of one task becomes the cue for beginning the next. Therefore, practice of the first task should include some cues and responses that will initiate the task or series of tasks which must eventually follow it. These overlapping cues and responses constitute a "bridge" connecting sequential tasks that makes their integration easier to learn even though the tasks themselves were first learned separately.

For example, during early training a student pilot having difficulty learning to maintain the proper rate of descent during a visual approach

could be provided additional practice on just this segment of the approach. When practicing just the final approach segment in an ATD, however, the practice should begin with cues signaling the turn onto the base leg which immediately precedes entry into the glideslope. Thus, the overlapping cues would establish a bridge linking earlier portions of the task with the one being practiced.

When such bridges linking separately practiced tasks have not been built during initial task practice, they can be added. Well-learned sequences of tasks can be integrated to form purposeful mission activities by adding during further practice the cue that initiates one sequence into the final part of a segment that is to precede it. Thus, the initial activity of a dive bomb task, transition from level flight to a roll-in, can be added to a visual navigation task in order to bridge the sequential tasks of visual navigation and dive bombing.

Verbal cues can be particularly useful in building bridges to integrate such sequential tasks. For example, a visually detected roll-in point for an intended target can be the final cue in a visual navigation task. Through verbal instructions to initiate an attack as soon as the roll-in point is reached, the identification of this point can easily serve as the initial cue for the roll-in on target. The verbal cue associated with having identified the intended roll-in point is all that is needed to make the navigation and dive sequences a single integrated task that, once practiced, can be easily recalled in its integrated form.

Integrating Simultaneous Tasks

Similarly, tasks that must be performed concurrently with other tasks, when practiced separately, should be learned in a way that helps bridge the isolation of the separate tasks. Weapons management and aircraft control during aerial combat are examples of tasks that are usually learned separately but must be performed concurrently during a combat mission. In interdependent tasks, cues pertinent to one may also govern responses normally associated with the other. In such cases, it is especially important that cues critical for one task be evident while practicing the other, thus again providing a link between the separately practiced tasks.

For example, sighting an enemy aircraft while on a reconnaissance mission is a cue to initiating offensive action and to selecting and arming the aircraft's guns. The two tasks, (1) initiating offensive action and (2) selecting and arming the guns, normally are practiced separately. While task (1) is being practiced, however, a verbal response such as "select guns" can be practiced at the time such action should occur relative to sighting the enemy aircraft and initiating the attack maneuver. Separately, while task (2) is being practiced, the words "select guns" can be employed as the cue to accompany initiation of the procedural task. With the cue to initiation of task (2) thus

incorporated into practice of task (1), integration of the two separately practiced tasks into a single mission task will occur more easily.

DURATION AND FREQUENCY OF PRACTICE

Three questions were frequently asked by persons interviewed during visits to aircrew training sites: How long should ATD practice sessions be? How long should a given task be practiced during a single session? How frequently should sessions occur? These questions cannot be answered categorically. Optimum practice schedules depend on a number of factors that vary with the tasks being trained, when they occur during the training program, and the relative skill of the aircrew students. The factors of primary concern in answering these questions are: (1) effects of interference; (2) level of previous learning; and (3) amount of forgetting during training.

Effects of Interference

The factor of most concern is interference. When learning a complex skill, lack of mastery of any one component of that skill may interfere with correct performance of another if they are practiced together. The result can be that neither component is practiced properly. Conditions under which tasks are usually performed, if they are included in the learning situation, can also be distracting when the tasks are being learned. As far as practice schedules are concerned, the issue is how practice can be arranged to avoid interference during early training when it would be detrimental.

Interference should be avoided when it confuses the identification of cues to be learned, or when it leads to unmanageable conflicts in the nature and magnitudes of responses. Such confusion and conflicts are indicated when progress during practice ceases. For example, in low altitude maneuvering a pilot must maintain a proper altitude above the ground while simultaneously keying on features of the terrain for navigation purposes. If it becomes evident during ATD practice that little or no progress is being made in coordinating these activities, altitude can be "frozen" (if the design of the ATD simulation permits individual parameters to be frozen) so the pilot can practice responding to terrain navigational cues without having to attend also to altitude control.

How long altitude should remain frozen depends on two conditions. First, some minimum of navigational skill should be evident. Second, because it would usually be desirable to practice both aspects of the skill as soon as progress can be made in both, the instructor should reactivate the altitude parameter when sufficient progress occurs in navigation. If progress can later be made while practicing both skills, then joint practice should continue. If not, brief practice on altitude maintenance alone should be tried.

In a number of instances, two tasks may be learned separately to a fairly high proficiency level, such as interpreting a radar track of a hostile aircraft and communicating with the ground. When they are practiced together for the first time, interference is likely, and some decrement in the performance of both can be expected. However, the thing to be learned during such practice is the integration of the two tasks, and as long as the integration progresses, practice is productive. But if performance on the integrated tasks becomes poorer as practice continues, then practice should cease temporarily.

Whether the break should be five minutes, an hour, a day, or several days depends on when the interference can be overcome. Experience with particular training problems must be the guide for determining the length of the break. If experience indicates that the confusion is transitory, take a five-minute break and try again. Relaxation during the break is desirable, rather than mental rehearsal of the problem task. If a training matter must be discussed, a topic unrelated to the task just practiced should be chosen. After the break, the task at hand should be reviewed, focusing upon the particular discriminations that are needed. The student should be aided in analyzing his problem, and provided guidance (including demonstrations if the instructor thinks they will help). If performance continues to deteriorate when practice is resumed, practice on that task should stop for the time being, but plans should be made for its resumption later.

If practice on a particular task must stop because of interference, but additional training time is available, another training task should be practiced. Usually, the best choice of an alternative task would be one that the student has previously done well, but for which more practice is needed. His previous (partial) mastery of the alternate task will reduce the likelihood of interference with (and from) the one just discontinued. He also will have a greater opportunity to be successful on the alternative task because of his earlier success with it, thus preventing unnecessary discouragement (see Chapter VII). A large number of alternative tasks are available in continuation training where maintenance of previously learned skills is a major concern. During earlier training there are usually few choices of tasks on which students have relative proficiency, but knowledge of a student's training history in relation to present training objectives would permit suitable alternative tasks to be selected. Emergency procedures that require periodic practice for maintenance are always likely candidates, of course, but so are most skills that are taught earlier in the training program. If a task must be selected that has not been performed successfully in the past, it should be one that is as different as possible from the one discontinued with respect to the types of cue and response discriminations required. For example, if practice was stopped on a flight control task, the next one should be a procedural task, or one involving voice communication, radar interpretation, weapons management, etc.

For the task that was interrupted, preparation should be made for a later return to it. The interference that caused progress to cease will dissipate on its own over time, provided practice was not continued so long that improper discriminations were learned. However, to aid in the dissipation and to guard against a similar problem next time, the student should be encouraged during the interim to analyze his difficulties verbally and to practice the task, slowly and deliberately, in his imagination. Further practice on the interrupted task should not occur until, as experience has shown, the student can be expected to resume progress toward its mastery.

How schedules of ATD practice can be adjusted to assure that interference does not have a detrimental effect upon skill development depends upon the sources of the interference. There are two major sources.

Inter-Task Competition

Learning a new skill can interfere with the retention and performance of a previously learned one, and learning one task can interfere with acquiring a subsequent one. Interference is greatest in either case during earlier practice trials when the cue-response discriminations are being learned; but even during later stages of training, partially learned discriminations may be required more rapidly than the student can make them. Interference will not occur, however, to the extent that the cues and responses corresponding to each task can be clearly discriminated from each other.

Interference is greatest when cue and response patterns for two tasks are similar, but the requirements for their use are different. For example, flight controls at fast and slow airspeeds feel different in many aircraft. If early ATD training sessions include both airspeeds, flight control "feel" at one speed becomes confused with that of the other. By gaining an intermediate level of proficiency at recognizing and responding to "feel" cues for fast speeds first, the "feel" at low speeds can be more easily recognized as predictably different from what is experienced at fast speeds. Once the difference can be discriminated, differential responses can be learned as well.

For two tasks with similar patterns of cue-response discriminations, practice should be scheduled so as to permit a minimum degree of proficiency to be developed on one before the other is attempted. If such separation is not possible, they should be practiced with enough time between them, e.g., on different days, so that the tasks themselves will not be confused with each other.

Many instances of inter-task interference during ATD training were reported in the interview conducted during the present project. Most frequently, the interference involved emergency procedures training. Malfunctions involving degraded aircraft control were introduced, for

example, before the student had developed adequate skills for aircraft control under normal conditions. Some temporary disruption in progress toward mastery of aircraft control skills almost surely resulted, ultimately increasing the amount of time and effort required to master the tasks of controlling the aircraft under both conditions.

The risk of deterioration in performance increases as the number of incompletely mastered tasks included in a practice session increases. This risk should be anticipated during the analyses that precede training program design so that deterioration can be minimized. Appropriate sequencing of tasks to be practiced could avoid the problem by and large, but the syllabus should also be flexible enough for instructors to reduce the number of tasks to be practiced at a particular time when performance deterioration is evident. The instructor could then introduce additional tasks when progress toward their mastery can continue.

Boredom and Fatigue

If practice continues when the student becomes bored or fatigued, the student will be practicing the behavior of not attending fully to the task. Discriminations will become lax, and progress toward skill development will suffer. Some instructors insist that this problem should not be a concern, that aircrew performance is often boring and fatiguing, "so the students may as well get used to it." In fact, some transport and bomber type ATD training sessions were noted to have been scheduled deliberately for long time periods in part to induce fatigue and boredom for that purpose.

It is important that aircrews learn to accommodate boredom and fatigue while maintaining high levels of skill performance. However, as with other interferences, their effects can only be detrimental when skills are being acquired. These or any other sources of interference should not be allowed to block rapid progress, or, because of student laxness, result in learning imprecise skills.

Onsets of fatigue and boredom vary with training tasks and types of ATDs. Instructor judgments are the best bases for deciding how long, and how often, various tasks can be practiced without risk of boredom and fatigue. Practice should be scheduled according to such decisions. However, even when lengthy ATD training schedules are necessary, both boredom and fatigue can be prevented simply by shifting the tasks being practiced. Switching from procedural to control tasks, from vectoring to gunnery, from instrument flight to aerobatics, etc., can result in renewed enthusiasm, especially when the second task is both more interesting and more challenging to the student.

Level of Previous Mastery

In their reviews of studies on skill retention, Prophet (1976) and Schendel, Shields, and Katz (1978) concluded that original level of

learning was the primary determiner of what would be remembered. To assure that a skill required on an operational mission will be recalled, the original level of learning therefore should be high. It is not sufficient to be able to perform a task correctly once, or even a few times, and then cease its practice and expect to be able to use it on a subsequent mission. Rather, skills must be "overlearned," that is, practiced well beyond the time proficiency is first achieved. A rule of thumb in deciding how much practice should occur for mission tasks is to continue practice until, as past experience has shown, correct performance can be assured the next time that task is performed.

The more thoroughly the tasks have been learned, the less the interference among them. Therefore, as mastery increases, finer and finer discriminations of cues and responses can be practiced with less danger of previously learned discriminations becoming confused with new ones. Also, as pointed out in Chapter III, discriminations are built on discriminations. So, not only is deterioration of skills during practice less likely after some discriminations have been learned, but transitory cessations of progress will be rarer as well, because the earlier skills can facilitate the learning of later ones. A pilot can learn more easily to maintain altitude above the ground when contour flying over varying terrain if he has first learned both to judge altitude at low levels over flat ground surfaces and to fly those maneuvers which permit him to cross mountain ridges without "highlighting" himself. These earlier skills would facilitate, not interfere with, low level altitude maintenance because they would be incorporated directly into the newer skill.

After at least an intermediate level of mastery has been attained on some tasks, relatively longer practice sessions will be possible without causing interference among tasks. So, as mastery increases, schedules for practice can be based on considerations other than interference. Within the limits of student fatigue and administrative efficiency, later ATD practice sessions should be as long as needed to ensure both meaningful task performance and session-to-session improvement in performance. Generally, as long as progress is maintained, total practice time during skill acquisition is less for fewer, longer practice sessions than for a greater number of shorter ones.

Amount of Forgetting

The requirement for scheduling practice to minimize forgetting is to provide practice at such times that the effects of forgetting can be prevented before they have serious impact on performance. An apparent failure to consider the need for continued practice to prevent forgetting was noted at one training site during the present project. Instructors complained that students who had achieved proficiency in maneuvers practiced early in ATD training had "forgotten" the skills by the time they reached an aircraft. Occasional practice of the tasks involved, spaced throughout ATD training, would have prevented the difficulty.

Thus, practice schedule requirements for minimizing forgetting may differ from those for original skill acquisition. The reason for this difference is that skills will be retained and ready for use to the extent that their cue-response patterns can be associated with the circumstances in which they are needed. Circumstances vary with time: Different types of maneuvers are flown; flights around or to new field locations introduce new terrain conditions and cues; new skills are learned, as are new integrations of old skills; new experiences accumulate with time, and responsibilities of aircrews change with professional maturity. Effects of those occurrences become superimposed so to speak on previous knowledge and skills, causing them to lose some of their original precision. Therefore, the skills to be maintained must be practiced under similarly varying times and circumstances so that later variations in cues and responses will not interfere with their performance.

Implication for Scheduling Training

Answers to the three questions asked at the beginning of this section can now be viewed in terms of the factors addressed above, i.e., the influences of interference during practice, the level of learning previously achieved, and the amount of forgetting during training. Whether the concern is the length of a single practice session, the amount of practice on a given task within a practice session, or the length of time between practice sessions, there are three rule-of-thumb criteria for decisions affecting schedules. These criteria are: (1) The time between occasions for practice should not be long enough for noticeable performance decrements to occur. (2) Since the effects of interference are greatest among incompletely learned tasks, frequent but relatively short practice sessions would be best for novices. (3) When the occasion for refresher training arises, especially with highly experienced aircrews, concentrated practice within relatively long individual sessions would probably be more efficient than practice distributed over a greater number of rapidly recurring short sessions.

SUMMARY

Five topics of concern in structuring ATD training were discussed in this chapter: establishing priorities for ATD use; sequencing ATD training relative to academic and flight training; allocating training among various types of available ATDs; organizing tasks into practice sessions; and determining the frequency and duration of individual ATD training sessions. The major points in these discussions are summarized below.

- Priorities for scheduling ATD use should be developed systematically, considering the needs for serving different groups as well as relative needs within each group. Priorities for training groups such as combat crews, instructors, maintenance personnel, etc., should be

defined, as should priorities for types of tasks such as aircraft control, emergency procedures, low level navigation, etc. These priorities should govern ATD use as its availability changes as well as during day-to-day training.

- ATD training priorities should optimize the effectiveness and efficiency of all available devices. Factors to consider are the kinds of training for which individual ATDs are best suited, relative effectiveness and efficiency of devices for training given tasks, cost of training, and availability of alternative media, including aircraft.

- Course syllabi should reflect training priorities and identify alternative resources. If an ATD cannot be available for training a given group or task because higher priority needs must be met, instructional personnel should be aware of alternative resources and their relative merits.

- ATD practice should be designed and scheduled to provide experience in the use of knowledge and concepts previously learned at the verbal level in academic training. Verbal knowledge must be related to concrete experiences if it is to have operational meaning. ATDs should be used to provide such experiences when feasible.

- When students have not had experiences needed for academic concepts to be understood, ATD experience of an appropriate kind should precede or be concurrent with academic training in those concepts. Verbal descriptions of ground effects, for example, and related coordinated control adjustments can have only limited meaning at best to a student who has never experienced ground effects. Experience with simulated ground effects (or actual ones in aircraft) will enable the student in his imagination to integrate control adjustments with conditions under which they occur.

- ATD and aircraft training should be sequenced as needed to maximize the contributions of both. No current ATD has perfect fidelity, nor can it simulate the full range of aircraft cues and reactions. Because of incompleteness of simulation, the full meaning of some ATD experiences cannot be understood until after similar tasks have been attempted in an aircraft. Rapid learning of discriminations of transferable cues and responses will often depend on timely experiences of similarities and differences between the aircraft and ATD.

- The experience level of a student should help determine how long are delays among related academic, ATD, and aircraft experiences. An experienced aircrewman has a repertoire of meanings and discriminations that enable him to derive more meaning than a novice can from most types of training experiences. He can also retain what he learns longer. Thus, timing of particular academic, ATD, and aircraft training can be more flexible for an experienced aircrewman.

- For any task trained in an ATD, key cues and responses related to the task should be represented meaningfully. To the extent such cues and responses can be visualized by the student, strict device fidelity is not needed. When cues and responses cannot be clearly imagined, training should be allocated only to ATDs with a necessary minimum of cue and response realism.

- If precise visual-motor skills are to be learned, precise performance must be practiced. When skills to be learned involve coordination of cue-response systems based on realistic kinesthetic and/or visual feedback, the ATD should have realistic control dynamics and provide realistic task-intrinsic feedback.

- The experience levels of students should be considered when allocating training to ATDs with differing capabilities. Fidelity of a given device is not as important for training an experienced aircrewman to perform a given task as for a novice. In his imagination, an experienced aircrewman can compensate for lack of fidelity. He can "see" an instrument change, "hear" an engine start, or "feel" an acceleration.

- Training should be allocated to individual ATDs according to their effectiveness and/or efficiency in training portions of tasks. When additional practice is needed for some parts of a task (e.g., vectoring an aerial intercept), but not for other parts (piloting the aircraft), similar training effectiveness and greater overall efficiency can be achieved if the portion requiring the greater amount of effort is practiced in a part-task trainer, thus freeing more comprehensive devices for other purposes.

- Training can be allocated to an ATD with characteristics different from a particular target aircraft provided that the skills being practiced are not specific to the aircraft. B-52 and C-135 pilots can profitably practice instrument flight skills in a T-40 trainer because the key aspects of these skills do not depend upon cockpit configurations, and very little upon the dynamics of particular aircraft.

- When two or more ATDs are equally useful for training a particular set of skills, allocation of training to a device should consider relative cost, overall program efficiency, and the preferences of the instructors and students. Operation and support costs vary among ATDs, and use of part-task trainers can free more comprehensive devices for comprehensive training. Both considerations are important. However, the preferences (usually for high fidelity devices) of instructors should be considered as well. Being forced to use less desirable ATDs, especially when a preferred one remains idle, will likely have a negative effect on user attitudes.

- Tasks should be broken down, or grouped, for practice so as to reduce cue/response complexity early in training, or to provide opportunities to accommodate complexity later in training. Efficient

training often requires reduced task complexity to avoid interference while learning basic discriminations. However, an aircrewman must eventually learn to accommodate all interferences characteristic of operational performance.

- Complex tasks should be broken down into parts, or subtasks, if it makes the parts easier to learn. Radio communication, for example, can be learned more easily if practiced separately from early attempts at aircraft control.

- Tasks should be separated from each other during early learning if such a separation aids cue discernment. The recognition of aural cues indicating engine malperformance can be difficult to learn if there are other unusual sound cues present as well.

- Tasks separated for practice should be divided so as to maintain integrity of the parts. An approach to a tanker for refueling can be practiced separately from station keeping after getting into position.

- Whatever separations of tasks are made, the resulting grouping should make sense to the student. He should be able to recognize the relations between the tasks practiced and overall mission performance.

- When tasks normally occur together or in a contiguous sequence, but are practiced separately, some cues/responses related to the omitted tasks should appear at appropriate times during practice. The purpose is to avoid isolation of the separate but interdependent tasks. By responding, at least symbolically, to real or imagined cues related to the omitted tasks, overall task awareness can be maintained, and the eventual integration of tasks enhanced.

- ATD practice sessions should be of a duration and frequency that permit steady progress during learning. Too long and too frequent practice sessions early in learning result in interference among cues and responses within tasks, and from one task to another. Practice should cease, or subsequent sessions be delayed, when progress ceases.

- Schedules for practice should prevent inter-task interference as much as possible. If two tasks are likely to become confused with each other if practiced together originally, either partial mastery on one task should be achieved prior to beginning the other, or practice on the separate tasks should be at different times, preferably on different days.

- Practice during task acquisition should not continue to the point that a student becomes unduly bored or fatigued. If students practice lackadaisical performance, they learn lackadaisical performance. Both boredom and fatigue can often be alleviated, however, by switching to a new task, especially if it is more interesting and challenging.

- As skill mastery progresses, practice sessions can be both longer and more frequent. Interference is less and less a problem as cue and response discriminations are learned.

- Practice sessions should be frequent enough to prevent unacceptable deterioration of skills. This holds for skill acquisition and for proficiency maintenance. Experience with retention of individual skills should be the basis for scheduling repetitive practice during training and for skills maintenance following training.

CHAPTER VI

ATD INSTRUCTORS

The notion persists that the characteristics and behavior of instructors are important factors influencing aircrew training effectiveness. Reviews of the literature on the flight instructor (Smode, Hall, and Meyer, 1967) and of ATD instructor utilization practices of the Air Force (Caro, 1977) have failed to find empirical support for this notion. Nevertheless, it was observed during the present survey that there tended to be differences among the prestige, the role, and the qualifications of ATD instructors, and that, intuitively at least, these instructor factors seemed related to the effectiveness of various ATD training activities. Specifically, in the ATD training activities judged to be more effective,¹ (1) ATD instructors are viewed as having special capabilities, (2) they are employed as flight instructors as well as ATD instructors, and (3) they are provided extensive training to qualify them for their use of ATDs.

ATD INSTRUCTOR PRESTIGE

Three factors were identified that could be characterized as influencing the prestige of ATD instructors. These factors are: (1) how the instructor was selected; (2) the priority given to his instructional duties vis-a-vis other unit duties; and (3) the kinds of assignments he would receive following a tour as an ATD instructor.

Instructor Selection

The ATD training activities judged most effective were those in which the instructors were selected from among volunteers who sought the assignment. The selectees typically were aircrewmen who had completed one but not more than two full tours in operational units and were judged by themselves as well as by their peers to have performed well above average in those assignments. They were Captains and junior Majors, and they were anticipating normal career progression and a career in the service.

The selection of ATD instructors in the more effective programs was made by personnel from the training unit on the basis of personal knowledge of the qualifications of the selectee and judgments as to the suitability of his personality. Personnel were sought who exhibited personality characteristics such as maturity and stability, believed to be conducive to the maintenance of favorable working relationships with

¹The basis for judgments of the relative effectiveness of the ATD training observed during this project is described in Chapter II.

peers and students. Knowledge of the selectee was gained in part through observation of his performance during periodic requalification training or flight performance checks. Before final selection, the candidates were typically interviewed by personnel from the training unit. The personnel doing the selecting were the instructors with and for whom the selectee would be working.

By contrast with the above, ATD instructors in the less effective programs were more likely to have been selected by an impersonal process, not to have volunteered for the assignment, and to have never been assigned to operational units as aircrewmembers. They tended to be of slightly lower rank (e.g., junior Captains), although some were more senior and were on a "twilight tour." They also tended to have spent a disproportionate amount of their prior service careers as instructors.

None of the noted instructor selection procedures had been validated, and no formal studies are known to have established a relationship between instructor abilities, experience, or personality and ATD or flight instructional effectiveness. Further, the selection procedures associated with the more effective training programs were informal in nature and may have been biased toward factors of little or no real significance. However, there are reasons to believe that these procedures were beneficial. It is believed that they served to identify and eliminate marginal pilots, those not wanting to instruct, and others whom the selecting instructor felt would probably be poor instructors. Furthermore, the esprit de corps of the instructors appeared to be increased by the fact that they were members of a "select" group, i.e., had survived a selection process operated by respected peers, and that their judgments as professional teachers were valued as a selection tool. (Chapter VII discusses the importance of instructor attitudes and professionalism.)

Priority of Instructional Duties

All military personnel are subject to extra duties that can detract from their primary duties. ATD instructors are no exception. In the more effective ATD training programs surveyed, however, instructional duties were given priority. Instructors tended to have relatively few competing additional duties, and they had more flexibility in scheduling their involvement in those duties than did their counterparts in other programs. Additionally, their workloads were managed so that the demands made on them did not detract from their instructional duties. Instructors were allowed time to prepare for ATD sessions before meeting with the students in recognition that, at some point, they need to review the students' history--strengths, weaknesses, performance problems, missing training elements--as well as the session objectives, performance criteria, priorities, and implementation procedures. Consideration was also given when instructors conducted ATD training during normally off-duty hours. The same instructors were not repeatedly scheduled for this

duty; and when they were scheduled for normally off-duty hours, they were given compensatory time off when possible.

The performance of ATD instructors in the more effective programs was assessed by training supervisors or STAN-EVAL personnel who conducted periodic proficiency checks. The major focus of these instructor evaluations was on the manner in which ATD training was conducted and the relevance of that training to the course objectives. These evaluations of proficiency were believed by the instructors to be weighed heavily in the determination of their job proficiency ratings.

By contrast, instructors in the less effective ATD training programs were more likely to view their involvement in those programs as "just another duty" that took up time they felt could be better spent elsewhere. They believed their effectiveness was assessed on the basis of their performance of their non-ATD related duties. In fact, they were generally unaware of any systematic efforts by unit supervisors to assess their effectiveness as ATD instructors.

The issue of instructor workloads and the scheduling of ATD activities during off hours is complicated. On one hand, schedulers feel that high fidelity ATDs are too expensive to let sit idle at night or on weekends. On the other hand, military personnel frequently have daytime collateral, or even primary, duties in addition to ATD instruction. They may therefore be required to work during normal duty hours and also at night or on weekends when it is necessary for access to an ATD. In cases where an instructor teaches late at night and then again early the next morning, fatigue and performance efficiency will be a problem. This situation is exacerbated by the fact that military personnel deploy for extended periods of time, so their off-duty time is needed for family relationships and other personal matters. In the long run, instructor effectiveness is likely to suffer unless duty schedules are such so as not to make training students a burden.

Subsequent Assignments

In many instances, ATD instructors viewed their current assignment as a neutral factor so far as a career-favorable subsequent assignment was concerned. In the more effective programs, however, instructors felt that they were given consideration in subsequent assignments commensurate with their skills and other qualifications. These were the same instructors who had been selected initially because of above average capabilities, and they expected that their capabilities would continue to be rewarded. They were able to cite examples of instructors who had preceded them who had experienced such favorable reassignment.

A negative factor related to subsequent assignment was pointed out by some of the instructors, however. In some units, ATD instructors were grouped for rating purposes. Where this occurred, instructors reported

that their assignment to the group would hurt their chances for a favorable rating and subsequent assignment. These aircrewmembers viewed themselves as significantly above average when compared with the overall aircrew population, but as more nearly average within their elite group. Thus their rating would be unrealistically--and unfavorably--depressed. The effect of such groupings for rating purposes was also noted to be a negative factor in continuing efforts to select the more capable instructors.

ATD INSTRUCTOR ROLE

There is no empirical evidence that indicates rated personnel are required for ATD training. As a general rule, nevertheless, ATD instructors are flight-rated aircrewmembers who instruct in aircraft as well as in devices. During the surveys, a consensus was noted that the use of rated personnel in all ATDs, even in CPTs, was desirable, for these devices could then be used for a greater portion of training. Rated aircrewmembers are able to provide mediational instruction as described in Chapter IV which compensates for lower device physical fidelity. Thus, they can train tasks with high cognitive loadings such as crew coordination and responding analytically to unusual emergency or tactical situations. The belief was frequently expressed that rated instructors, in contrast to nonrated personnel, are often able to provide supplemental information about flying and airborne system operation, thus creating training situations in all ATDs that have greater realism and functional similarity to operational tasks. Also, flight-rated ATD instructors can provide mediational instruction which helps integrate ATD and aircraft training. Indeed, in many units, the same instructors were found to be used for a student's ATD and aircraft training.

In addition to their increased instructional capabilities, many units felt that rated aircrewmembers were necessary to improve the credibility of ATD training and to promote its acceptance. For example, given an emphasis on the inclusion of only "need-to-know" information for ATD training, many units felt that rated instructors were necessary to give credibility to such information. Additionally, use of rated instructors was viewed as a manifestation of command emphasis on ATD training.

There are exceptions to the use of flight-rated personnel to instruct in ATDs, however. In the case of some older instrument procedures training devices employed in undergraduate-level training, nonrated personnel are employed as instructors. Some of these are civilian employees who were formerly flight rated military personnel. Also, some ATDs are manned by nonrated device operators or technicians who sometimes function as instructors when a flight-rated aircrewman is not available to conduct training in the device. This latter practice was generally viewed as inappropriate by the aircrewmembers who had participated in such training, reportedly because the technicians were

insufficiently knowledgeable with respect to situational factors that tended to arise during such training. Technicians, for example, might unknowingly introduce unrealistic compound malfunctions which would inevitably cause a crash.

The assumed advantages of using nonrated personnel are that training personnel costs are lower, demand for rated personnel and especially rated instructors--currently a precious resource in the military--is not as high, and under-utilization of rated personnel inherent in some routine task assignments is reduced. So far as could be determined during the current project, there have been no formal studies to determine the effectiveness of the use of nonrated personnel to instruct in ATDs.

The ATD training programs that were judged most effective did employ instructor pilots in the dual role of flight and ATD instructors, and the same instructors were scheduled to conduct both flight and ATD instruction for a given student. The few programs surveyed in which the roles of ATD and aircraft instructors were assigned to separate individuals were judged less effective, as were those in which device operators were permitted to conduct instruction when qualified aircrewmembers were absent.

ATD INSTRUCTOR TRAINING

The structure and content of ATD instructor training programs varied widely among the activities surveyed. The training ranged from a "checkout" on the device's instructor console during which the location and function of controls and displays were illustrated, to a comprehensive program involving training in instructional technology (encompassing some of the information contained in Chapters III and IV of the present report), instruction on how and when to employ the device's instructional features, and the conduct of ATD instruction under the supervision of a qualified instructor. The programs that were judged to be effective were also the programs in which the instructor training was judged to be comprehensive and formally structured.

Several ATD instructor training programs included in the survey were found to have features that one would expect to produce well-qualified instructors and, in turn, effective ATD training for student aircrews. One program conducted for ATD instructor selectees was judged to be particularly good with respect to content and structure. Principal features of that program are described below.

The program consists of four phases. During the first phase, the newly selected instructor goes through the instructional program he has been selected to teach. Thus, in the role of a student, he receives all instruction, including that given in the ATDs and in the aircraft, that other students receive. The purpose of this phase of his training is to

sure his own competence as an aircrewman and to assure that his performance of all aircrew tasks conform to specified standards. Additionally, the instructor observes ATD instructional techniques as they are viewed by a student and becomes familiar with the content and mode of instruction in the course he will teach.

During the second phase, the instructor selectee observes the administration to two students of the course he is being prepared to teach. During this activity, he observes and is instructed as to (1) the operation of the ATDs, (2) the use of instructor job aids (e.g., lesson guides, grade slips), and (3) the employment of ATD instructional support features for the training he will conduct. Concurrently, he is tutored on an individual basis by a qualified instructional technologist concerning the principles of instruction and how those principles may be applied to the training that he will conduct. Additionally, to promote acceptance of ATD training, the instructor receives information on the value of ATD training in the program he will teach and on the value of ATD training in general.

During the next phase, the instructor selectee conducts selected portions of the training program he is preparing to teach, with a qualified instructor playing the role of a student and presenting the instructor trainee with common student problems. Following each training period, he and the "student" review and critique his performance. The purpose of this activity is to ensure that he knows why he does what he does, as well as how to do it.

Finally, the instructor selectee is assigned two incoming students to train. This fourth phase of his preparation consists of the training of these two students under the supervision of a qualified instructor. Thus, the final phase of his training is supervised "practice teaching," during which he continues to be critiqued as necessary by the supervising instructor. At the conclusion of this fourth phase, he is considered to be a fully qualified instructor.

To improve the efficiency of this rather extensive instructor training, proficiency advancement is used throughout all the phases of the course. Progress in instructional performance, in addition to aircrew skills and knowledge, is used as the principal basis for advancement through the course. Additionally, the instructor trainee's workload is managed so that the demands of collateral duties do not detract from his studies. Finally, commensurate with the importance placed on instructor training, the job evaluation reports of the instructor trainee reflect the evaluation of his performance in the instructor training course.

It was also observed during the present study that it was not just the adequacy of the initial instructor training that influenced the competency of ATD instructors, but also the adequacy of the continuation training that they received. In most units, ATD instructors participated

in continuation training that was designed to maintain only their aircrew, and not instructional, skills. In a few units, however, the instructors received regularly scheduled continuation training designed to refresh, refine, update and expand their ATD instructional capabilities. Training specialists, ISD personnel, or ATD training officers were employed to provide this training on an individual or group basis. There were also supervised instructor workshops, seminars, and bull sessions that were designed to encourage instructor communication about personal experiences with various ATD instructional techniques. Individualized remedial training was provided to address deficiencies identified in an instructor's performance during the routine evaluation of his instructional skills.

There are no data to demonstrate conclusively that any part of this instructor training is critical to the effectiveness of instructors. It may well be that other factors, e.g., the basis for their selection and the status they are afforded, would more than account for the fact that the ATD programs they are conducting were judged to be among the best surveyed.

SUMMARY

This chapter discussed three topics of concern regarding ATD instructors: instructor prestige and factors that govern it; instructor roles and aircrew skills required to fill them; and instructor training needed for effective ATD instruction. Major points in these discussions are summarized below.

- The selection of personnel to be ATD instructors should be based on their desire and ability to do the job. The most effective ATD instructors are those who seek their assignment, demonstrate a well above average level of performance during prior assignments to operational units, and are mature, stable individuals who work well with other people.

- Instructional duties of ATD instructors should be given priority. The workload of ATD instructors should be managed so that the demands made on them do not detract from their instructional duties nor create unpleasant conditions for the conduct of those duties. Moreover, evaluation of instructional proficiency should be weighted heavily in overall instructor job proficiency ratings.

- ATD instructors should be given consideration in subsequent assignments commensurate with their skills and other qualifications. ATD instructors should be treated equitably with respect to their peers in other billets. If they receive insufficient rewards, it will be difficult to staff ATD positions with capable, motivated personnel.

- ATD instructors should be flight rated crewmen when the instruction involves other than established procedural tasks. The knowledge gained through experience as an aircrewman will contribute to effectiveness when instruction involves adaptive behavior, cognitive skills, generalizable skills, and factors that contribute to an awareness of overall mission requirements and activities. Additionally, the use of rated personnel permits the use of the same instructor for a student's ATD and aircraft training.

- ATD instructor training should be comprehensive and formally structured. It should assure that his performance of aircrew tasks conforms to specific standards, that he has a practical knowledge of instructional technology, including how and when to use a device's instructional features, and that he understands the value of ATD training.

- The instructor trainee should receive practice in conducting instruction in the ATD with supervision and critiques provided by a qualified instructor. Practice teaching helps the instructor trainee to gain proficiency in ATD operation and to become familiar with desired training techniques. It should also be used to review common student problems, thus giving the instructor guided practice in helping students solve problems.

- Evaluation reports for instructor trainees should reflect their achievements in the instructor training course, and advancement through instructor training should be on a proficiency basis. Evaluation of instructor achievement and proficiency should be based primarily on instructional performance but also on competence in the aircrew skills and knowledge they will teach.

- Throughout his tenure as an ATD instructor, the instructor should receive continuation training designed to refresh, refine, update, and expand his ATD instructional capabilities. This training should be scheduled on a regular basis employing training specialists, ISD personnel, or ATD training officers to provide individual and group continuation training to the instructors. If deficiencies in an ATD instructor's proficiency are identified during routine observations of his instructional skills, the instructor should receive remedial training designed to remove these deficiencies.

CHAPTER VII

THE INFLUENCE OF ATTITUDES ON ATD UTILIZATION

Many reviews of ATD training have noted that the attitudes of training personnel toward ATDs exert a significant influence on the effectiveness of their utilization (e.g., Miller, 1953; Muckler, Nygaard, O'Kelly, and Williams, 1959; Smode, Hall, and Meyer, 1966; General Accounting Office, 1975; House Armed Services Committee, 1978). The current review is no exception. Units in which ATDs appeared to be more effectively used were characterized by a dominant positive attitude toward that training, while negative attitudes prevailed in units where they were less effectively used.¹

The most direct evidence of the attitudes of training personnel toward ATDs is their willingness to use the devices. Personnel responsible for the development of aircrew training programs who expressed unfavorable attitudes toward ATD training tended to prescribe use of those devices for a smaller and less significant portion of the total training program than would be potentially possible. Additionally, instructors and students who held a low opinion of the training value of the devices, when given the option, tended to avoid using ATDs regardless of their potential training value.

Even when ATDs are used, negative attitudes toward the devices can still thwart effective instruction. For example, a low opinion of ATD training on the part of some managerial personnel surveyed appeared to result in the assignment of less capable personnel as ATD instructors and less attention to maintenance support for the devices. ATD training appeared to be thwarted also by instructors and students who viewed ATDs negatively. On several occasions, personnel who held such views reported practices that included conducting overly simplistic training, performing exotic maneuvers that would never be required in the aircraft, devising ways to outwit the device (sometimes referred to as "pinballing" it), and drinking coffee for as much as half of a scheduled ATD session.

Perhaps the most pervasive and distressing consequence of negative attitudes toward ATD training was the continued acceptance in some units of recognized ineffective and inefficient ATD training by managers, training developers, instructors, and students. These personnel were usually able to identify major deficiencies in their ATD training programs, but they often seemed unwilling to do anything about the problems because they felt it would not be worth the effort. As one officer-in-charge of ATD training put it, "Why worry when no one cares about ATD training anyway?"

¹The basis for judgments of the relative effectiveness of the ATD training observed during this project is described in Chapter II.

It is clear that the valence of attitudes toward ATD training can exert a significant influence on ATD utilization. If attitudes are positive, then everyone wants and tries to make ATD training work. If attitudes are negative, then no one cares if it does not work. In a few cases, there even appeared to be attempts, perhaps unconscious, to make it not work so there would be no bother with more ATD training. Thus, given the importance of attitudes toward ATD utilization, the development, conduct, and management of ATD training should ensure that personnel actions, and the products of those actions, promote the formation of favorable attitudes toward ATD training. To that end, the purpose of this section of the report is to provide information about factors that influence the formation of attitudes toward utilization of ATDs.

FACTORS INFLUENCING ATTITUDES TOWARD ATD UTILIZATION

Very few studies were identified during the literature review that dealt with attitudes in relation to the utilization of training devices. The principal study of direct relevance, one by Mackie, Kelley, Moe, and Mecherikoff (1972), examined factors that were hypothesized to influence user attitudes toward specific training devices and developed a scaling and profiling technique to assess those attitudes. Since their study is the only investigation that examined specific attitudes toward ATDs, it was used to a great extent in the preparation of the following discussion. Readers who desire further information regarding the assessment of factors influencing attitudes towards ATDs should consult their report.

Other studies addressed the more general topic of the influence of attitudes on the acceptance and utilization of new operational equipment, new training devices, new or modified operational and training procedures, advanced technologies, and other kinds of changes introduced in military, educational, industrial, and other organizations (Lyons, 1966; McClelland, 1968; Mecherikoff and Mackie, 1970). Of particular interest among these was the study by Mecherikoff and Mackie which reviewed the basic psychological literature on attitude change. Their purpose was to provide practical guidance that could be used to promote the formation of positive attitudes toward organizational changes of all kinds. Readers interested in the broader issues involved in influencing attitudes toward changes are referred to their report.

Factors that influence attitudes toward ATDs can be divided into three categories to facilitate this discussion. These categories are: (1) the design of the ATD itself; (2) the introduction of the device to the using organization; and (3) the manner in which ATD training is conducted and managed.

ATD Design

Three aspects of ATD design are of interest here: the fidelity of the device, i.e., its physical appearance and dynamics; the

Instructor/Operator station; and the extent of user participation in the process of designing the device.

ATD Fidelity

Physical fidelity, particularly with respect to flight dynamics or handling characteristics, has long been recognized as a major determinant of personnel attitudes toward ATDs and ATD training (Mackie et al., 1972; Miller, 1954). The importance of physical fidelity is due in part to the dominance of the aircraft as a model for ATD design. Flexman (cited in Muckler et al., 1959) noted that, "If the simulator looks, acts, feels, and sounds like the aircraft, the trainee is more likely to be convinced that practice in the device will be beneficial to him." Training personnel reflected this view when they observed that the greater complexity of simulators with motion platforms and external visual displays seemed to make ATD training more "impressive." These personnel also expressed the view that high physical fidelity ATDs provide a degree of realism necessary to stress the student ("provide a pucker factor"), and that training in them is less boring and more fun for both the students and instructors.

Not all of the attitudes attributable to ATD design were based strictly on physical fidelity considerations. Some expressions of attitudes revealed an understanding of ATD training requirements and of the deficiencies or strengths of ATDs in satisfying those requirements. Thus, some negative attitudes apparently attributable to low physical fidelity were based on perceptions of design deficiencies resulting from the mismatch of device design with specific training requirements. However, given the incomplete definition of training requirements at many of the units surveyed, it was usually difficult to determine whether attitudes attributed to low device fidelity were warranted or unwarranted.

In recognition of the influence of fidelity on attitudes, and in the absence of clear statements of training objectives and the relationship between those objectives and ATD design requirements, many organizations have consciously tried to "buy" favorable attitudes toward device training through the acquisition of high fidelity ATDs. This practice characterized the procurement of simulators by several of the major airlines during the early to mid 1960s and has been a factor in several military device procurements since that time.

On the other hand, it would be incorrect to assume that low fidelity devices always engender poor attitudes. Such is not the case. Favorable attitudes have been observed toward training in quite low physical fidelity devices. For favorable attitudes to be found, however, it is essential that the lower fidelity devices be properly used. For example, these devices must be used only to meet training objectives that are consistent with their part-task training potential. Further, the training programs developed for lower fidelity devices must employ cognitive processes, as explained in Chapters III and IV, to develop the

cue discriminations essential for subsequent transfer to operational aircraft.

Although physical fidelity is a significant influence on attitudes toward the utilization of ATDs, it should not dominate ATD procurement decisions. Nor should it be the sole basis of allocation of training objectives to ATDs. As discussed in Chapter V, the decision to use ATDs as a training resource should be based on a number of factors in addition to fidelity. ATD training should incorporate the value of and correct methods for use of ATDs of all levels of fidelity. Training effectiveness should then be demonstrated so that training personnel can have a basis other than fidelity for forming favorable attitudes toward ATDs.

IOS Design

The Instructor/Operator Station is the interface between the ATD instructor and the device. The efficiency of the instructional process is dependent to a large extent upon how suitably designed this interface is with respect to the instructional process. Several of the more complex ATDs surveyed were viewed by the assigned instructors as being poorly designed. They spoke disdainfully of these devices' IOSs and the instructional features operable from them. Specifically, comments were made to the effect that some necessary functions were made difficult because of poor IOS designs.

Problems that were cited included inadequate human engineering of displays and controls (e.g., difficult to see or reach, lack of labels), cumbersome input tasks for interacting with the computer (e.g., lengthy keyboard entries for commonly used functions), cockpit repeater instruments that were arranged differently from those in the aircraft (thus presumably conflicting with highly developed scan patterns), instructional features that were inappropriately designed with respect to training requirements (e.g., record/playback feature controls did not allow instructors to reconstruct needed portions of tactical intercepts), and poorly organized CRT displays. Similar problems have been noted in studies of IOS and instructional feature designs by Charles, Willard, and Healey (1976), and Isley and Miller (1976).

Mackie et al. (1972), reported that such IOS design deficiencies created problem set-up and performance measurement difficulties that adversely affect the acceptability of devices so far as instructors are concerned. Some instructors interviewed during the current project did reflect generally unfavorable attitudes that appeared associated with their frustration in using IOSs and their poorly designed features.

The instructors' inability to use some of the devices in question in an efficient manner could be attributed to inadequate instructor training. Therefore, all observed negative attitudes toward IOSs could not be attributed solely to poor design. Nevertheless, some of the

deficiencies cited by the instructors were readily apparent even to a casual observer and could easily account for the attitudes noted.

The ATD Design Process

Studies of the use of new equipment and other innovations (Mecherikoff and Mackie, 1970) indicate that user attitudes toward new equipment are influenced by perceptions of the adequacy with which the design process took user needs into consideration. If esteemed representatives of the users were employed as part of the design team, and if extensive inputs were seriously sought from the user community, then attitudes toward the equipment tended to be favorable. This relationship between the design process and ATD user attitudes was noted in interviews conducted during the current survey. Attitudes of some training personnel toward ATD training appeared to have been shaped by their perceptions of the adequacy of the procedures employed for the design of the ATD and its associated training programs. When users were more confident that the designers of the device and training programs were competent and had taken the users' viewpoints into consideration, then the users felt more positive toward the device, even though user expectations may not have been fully realized.

Currently, simulator design and procurement agencies stress the value of user participation and input during ATD design. In units that had just received new devices or were expecting devices in the near future, personnel often voiced confidence in the device because personnel from their unit had "been there" during the design. In one organization several years after the introduction of a device, it was still well known that the design of the ATD and training program represented the input of some of that unit's best pilots, many of whom were known by name by most of the training personnel. This was cited as a factor in building their confidence in ATD training.

In contrast, some ATDs were reportedly designed in isolation from users and "dumped over the fence at night." In such cases, the current users felt that they had been isolated from ATD design and training development. Interviewees in these units referred to an anonymous "they" who "didn't know what we needed" in the ATD or who "didn't know how we train our aircrews."

It was not possible during the current survey to verify that these devices' designs were really inappropriate to the training units' needs. In several instances, the complaints appeared valid. In any event, such comments reflect a "not invented here" syndrome that has been identified elsewhere as a cause of negative attitudes (Mecherikoff and Mackie, 1970). It would appear that developing devices in isolation from future device users is a practice that could and should be avoided, in the interest of obtaining better ATDs as well as more positive attitudes toward these devices. Guidance concerning the employment of users, training specialists, and other personnel on ATD design teams can be found in reports by Swain (1954) and Smode (1972).

Involving the user in the ATD design process, while highly desirable, cannot assure that the device will conform to all user expectations. Some disappointments can be expected simply because the ATD procurement process must be responsive to factors other than user desires. These factors include engineering constraints and cost. In addition, the time between initiation of a requirement for an ATD and the delivery of that device (five years is not uncommon for the more sophisticated devices) introduces other factors. For example, training requirements themselves can change in such a manner that the device's design is no longer optimum. Further, it is often impossible to maintain continuity of personnel involved in an ATD development project over extended time periods, and the reasons for particular device features may be lost as personnel changes occur.

An effort was made during the study to determine the role of ISD team personnel in ATD design. One might assume that, by virtue of their efforts to define training requirements, these personnel would be influential in specifying characteristics of ATDs for "ISDed" training programs. Such was not found to be the case, however. There appeared to be three reasons: (1) ISD teams are typically understaffed and do not have the resources to devote to equipment design; (2) most ISD design efforts are conducted too late in the device development process for the ISD results to define device requirements (i.e., device designs are often frozen before ISD teams can provide relevant information); and (3) ISD analytic techniques tend to concentrate on definition of criteria for training rather than on training process information of the kind that would define ATD requirements unique to a particular training program. Thus, rather than being influential in defining ATD designs, ISD teams generally must accept as resource constraints the devices to be made available for the training programs they design.

ATD Introduction

Procedures employed during the introductory phase of ATD training appeared to have an influence on initial attitudes toward that training. These initial attitudes also appeared to contribute to the determination of how the ATD was used during the remainder of its life cycle. Of particular note were factors concerned with (1) the roles of managerial and instructional personnel; (2) activities conducted in preparation for the introduction of the ATD; and (3) the manner in which the devices were introduced.

Personnel Roles During ATD Introduction

In some units, the personnel who were to be in the initial ATD instructor cadre participated in selected device development and testing activities (e.g., in-process reviews, factory acceptance tests, and OT&E). Several instructors who had done so felt that their initial "hands-on" experience and personal involvement with the development and testing of the ATD was a major factor in the formation of their own

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Management of the Introduction

First impressions are important to attitude development in almost all endeavors. First impressions toward ATDs invariably influence attitudes toward ATDs. To promote effective ATD training during the crucial introductory phase, some units made sure that all elements of the training system were functioning according to expectations (e.g., the ATD, the training program, and the instructors) before aircrew training activities were permitted to begin. In these units, the devices were perceived as effective, and attitudes were positive.

In other units, near chaos seemingly prevailed at the time the devices were made available for training. The ATDs were used for training even though they were not really ready (e.g., they needed additional "tweaking" to prevent frequent interruptions), the training program was only partially prepared, and the instructors had not been fully trained. In the latter units, the devices were viewed less favorably even after the initial start-up problems had been solved.

The Conduct and Management of Instruction in the ATD

The Influence of Instructors' Attitudes

Students, particularly those undergoing UPT and initial transition training, will feel toward ATDs as others do, and behave during training sessions according to how others act. It is not sufficient to attempt through fiat to shape students' attitudes. Students will model others; they will do what others do, not what others say. If an instructor asserts that an upcoming ATD session is important, but shows by other comments or by example during the session that what occurs is not really important, the student will base his judgment on the latter indications. Put bluntly, if instructional personnel do not value ATD training, students will not either, regardless of what is said.

During training site visits, a problem regarding student "cultures" was evident at those sites where instructors held ATDs in low esteem. Specifically, students as a group conformed to the instructors' views of the devices. Even training sessions with ostensibly valuable objectives were often referred to as "squares to be filled." Instructors' attitudes toward ATDs, whether individual devices or in general, appeared to be the most important single variable in determining student perceptions of ATD training value at these sites.

In many units, a single individual or a small group of individuals served as advocates for ATD training. These individuals were typically highly motivated, aggressive instructors, training developers, civilian training specialists, or training managers who took on the responsibility, often without visible command support, for assuring that ATD training was conducted effectively. Simply put, they cared about ATD training, and the dedication they showed appeared to influence the attitudes of other personnel. By contrast, in some units without a

strong advocate, ATD training was recognized as being ineffective, but no one seemed interested in doing anything about it. Everyone more or less put in the required time in the device and assumed the system would somehow work, but there was a notable absence of positive views of the worth of ATD training. Advocates are needed to question such complacency and to promote effective ATD training.¹

Course Syllabi and Training Scenarios

Mackie et al. (1972) found that a major factor related to attitudes toward ATD utilization that was associated with the instructional process was the presence or absence of adequate training program syllabi, scenarios, and other training courseware. During the present study, several instances were noted in which ATD courseware was incomplete or poorly prepared. Although the possible influence of this factor on the attitudes of the personnel interviewed was explored, none was found, except to the extent described in the immediately following paragraph. (However, one might assume that a failure to prepare adequate courseware, a situation noted at a few units, is indicative of an attitude of complacency.)

The above comments notwithstanding, attitudes were found to be influenced by the perceived realism of training syllabi and scenarios and the completeness of performance evaluation scenarios conducted in the device. Some aircrews reported that they dreaded ATD training because that training was made so much more difficult than training in the aircraft. Their ATD instructors often inserted training events such as systems failure at a pace that was unrealistic and too rapid for the students' skill levels. Even with highly skilled pilots, system failures were being inserted in such rapid succession that the pilots could no longer cope with the situation, let alone accomplish a useful training mission. The general problem was that a few instructors used the device's instructional features to make ATD training sessions extremely intense, even to the point of apparently attempting to embarrass the student. Students, although they often realized the value of properly conducted ATD training, soon developed apathetic and even hostile attitudes toward ATDs because they were frustrated by their failures. Experienced aircrews resisted the use of these ATDs even for proficiency checks, because they feared the tests would be unrealistic and it would be impossible to perform well on them.

In general, however, students and instructors interviewed during the present study did not identify ATD instructional techniques and methods per se as being a major factor influencing their attitudes toward ATD training. Students frequently mentioned problems with specific

¹A common finding in the literature on attitude change in such situations is the need for advocates. Such personnel should be especially selected, trained, and managed to promote positive attitudes toward the subject of their advocacy

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regarding key indicators of student progress can be especially valuable, for they permit the student to observe systematic changes in task proficiency over time when those changes may not be discernible on a given day. (The role of feedback in ATD training is discussed further in Chapter IV.)

Instructor approval. The student must perceive that he and his efforts are respected and valued by significant persons, especially his instructors. The nature and manner of feedback from instructors during day-to-day associations are crucial to maintaining positive student attitudes. Being told "You did a good job" taps the basis for social behavior in general. Its power is such that additional specific negative feedback can be perceived as attempts to help the learner rather than to punish him.

Critical evaluations of students must necessarily occur during training. Unless the student can recognize that he has made progress, however, and that the instructor values his progress, critiques of performance will almost surely be discouraging. With recognition that he is making valuable progress, negative feedback is much more likely to be interpreted for what it should be: information necessary for further improvement.

In other, more subtle ways, students receive communications from training personnel that are very revealing of the value placed on them. The nature and amount of nontraining duties they are assigned, whether training is often conducted after normal duty hours, and various other training policies and practices, all tell the student something about how those responsible for training view him, and the priority placed on training. Is learning to be a quality aircrewman the overriding goal? Often, answers are revealed through policies that facilitate this goal, or contrarily, interfere with its attainment.

Management of ATD Training Resources

Management's job is to enable effective ATD training to take place. When management does not perform this job in a manner satisfactory to the personnel involved, ATD training may become a focus for criticism. Managerial practices relating to training, resource scheduling, and maintenance were commonly criticized as unpopular during the present survey, and similar findings have been reported previously (Mackie et al., 1972).

Some units scheduled ATD training late at night and still expected a full workday the next day for the students involved. Additionally, late or early ATD sessions often resulted in extremely long hours for instructors without adequate recognition of their efforts or compensating time off. In some units, students were protected by regulations from such abuse, but not in any of the continuation training units visited.

The scheduling of ATD training during normally off-duty hours is a wide-spread practice. The reliability of modern devices can support 20 or more hours' training per day. In some units, the management policy was to designate personnel for specific shifts of not more than 8 hours per day to make full use of the available time, a practice employed also by many commercial airlines. In several continuation training units visited, however, some instructors were scheduled for in excess of 8 hours per day with a consequent unfavorable impact on their views toward ATDs. This practice was incorrectly compared by unit management with the airlines' use of devices for almost continuously scheduled training activities. Airlines schedule almost continued device use, but personnel work normal hours. This mistaken concept of optimum use of ATDs had an obvious impact on instructor attitudes.

Requirements that mandated a minimal number of hours of use of an ATD were also extremely unpopular. (Mandated ATD utilization rates are discussed in Chapter II.) Students and instructors told of wasting time in the ATD, and even of being dishonest in the recording of ATD utilization time, to help their unit meet mandated rates. The effect that this practice had on their attitudes toward ATD training was to suggest that the training itself was unimportant and to be avoided when possible, an attitude that was encountered repeatedly during the present project.

Lack of device availability, disruptions during training, and training with degraded systems because of inadequate ATD maintenance support and parts availability were cited as factors leading to negative attitudes toward ATDs. Such problems were noted primarily among older devices. The reliability of current generation devices is such that complaints concerning their availability for scheduled training activities were rarely noted, and those complaints that were noted were restricted primarily to visual system alignment/adjustment problems and failures of flight director instruments in the cockpit. However, over an extended period following introduction of a new ATD, training in one unit reportedly was interrupted on the average of two to three times per session by computer malfunctions. While these interruptions were short, the loss of continuity of training was frustrating. Instructors reported becoming so frustrated with such interruptions that they would cancel a training session. Having to use ATDs with such problems resulted in lowered opinions of new ATDs among personnel who must use these devices. Fortunately, such disruptions are uncommon after the devices have been in use for several months and "debugging" has been completed.

In an effort to reinforce positive attitudes toward ATD training, some users provide relatively plush facilities for that training. In one unit where this practice was employed, personnel cited the design of the facilities as a positive attitudinal factor. However, in units that could be characterized as having ineffective ATD training, comparably new facilities were described as "sterile showcases," and attitudes toward ATD training were generally negative.

Frustrations generated by labored use of poorly designed displays and controls will result in lowered opinions of ATD training in general.

- Training personnel who will be eventual users of an ATD should participate in the design of the device. It is not just the design of the device that influences user attitudes, but also their perception of how well the design process took their expressed needs into consideration. Participation of users in the ATD design process will influence the formation of positive attitudes toward the ATD.

- Training personnel who will be eventual users of an ATD should participate in the initial evaluation of the device. User participation in device testing will tend to influence their opinions positively toward ATD training.

- Individuals within the training organization should be encouraged to become advocates for ATD training. Advocates are needed to guard against the complacent acceptance of ineffective ATD training and for adequate support for that training. Such personnel should be specially selected, trained, and managed to promote positive attitudes toward ATD training.

- Planning for the introduction of a new ATD and for the implementation of ATD training should begin early in the ATD procurement process and should be given strong management support. Transitions to a new device and a new training program will be smoother if difficulties associated with change are anticipated and provisions are made to minimize problems.

- Changes in training that might disrupt established procedures should be made independently of ATD introduction. Such changes should be initiated before a new ATD is introduced so that the instructional staff can become familiar with them and can develop confidence in their use.

- All elements of the training system should be functioning according to expectations before ATD training is permitted to begin. The perceived effectiveness of ATD training during its introduction is crucial to the formation of initial attitudes. The ATD should not be used until it meets all specifications. Support for training (e.g., instructor training, maintenance support) should also be fully implemented before training commences.

- ATD instructors should serve as effective role models who encourage the formation of positive student attitudes toward ATD training. During the operational utilization of the ATD, the key factor influencing student attitudes is the attitudes of their instructors. Procedures used to select, train, and manage the instructors should be designed to foster proper instructor attitudes as well as to develop effective instructional skills.

- The content and pace of ATD training should be appropriate to the student's skill level. Overloading the student with inappropriately difficult training, in addition to being inefficient instruction, fosters the development of unfavorable student attitudes toward ATD training.

- Student learning should be effectively managed so that they maintain favorable attitudes toward ATD training. Four requirements should be met. Students should: (1) understand the significance of each task and the need for its mastery; (2) make progress toward mastery of relevant skills during each practice session; (3) perceive that progress is being made; and (4) perceive that they and their efforts are respected and valued by significant persons, especially instructors.

- Excessive demands should not be made on the time of ATD instructional personnel. Schedules of ATD utilization that create excessive demands on instructor's time, particularly during normally off-duty hours, will adversely affect attitudes.

- Professionalism in ATD training should be deliberately fostered. The fostering of professionalism in ATD training is the most important responsibility that ATD training managers can assume in ensuring favorable attitudes toward ATD training. A professional atmosphere should be established in which effective instruction is given the highest unit priority.

the 1990s, the number of people in the world who are under 15 years of age is expected to increase from 1.1 billion to 1.5 billion. The number of people aged 65 and over is expected to increase from 250 million to 450 million. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion. The number of people aged 15 and over is expected to increase from 3.5 billion to 4.5 billion.

ATD training might also be considered effective if it results in skilled performance of a task in the device itself. In such an instance, it would be necessary for performance in the ATD to correspond closely with that in the aircraft. The correspondence could have been established earlier by an empirical study, or by an analysis of the cue-response equivalence of the ATD and aircraft. Under these conditions, training effectiveness could be measured in terms of improvement in performance in the device following practice. Performance in the aircraft would be assumed to correspond to the improved ATD performance.

Evaluation of effectiveness in terms of improvement in performance in the device is especially needed when performance cannot be evaluated safely or economically in flight. For example, the effectiveness of training related to operation of an aircraft during emergencies, such as when a single-engine fighter experiences a power failure, can be measured in an ATD by simulating such a failure and determining whether, after training in the device, the pilot has learned to cope appropriately with that situation. In this manner, the effectiveness of the training can be

assessed without endangering the pilot or the aircraft. Similarly, the effectiveness of weapons delivery training in a weapons system trainer can be evaluated without the expenses and potential risks associated with weapons release in actual flight by determining whether skills develop in the device. Again, however, it is necessary that the equivalence of ATD and aircraft performance be established empirically or analytically.

When circumstances and resources permit, however, assessment of performance in flight through a transfer of training study is a more satisfactory approach to determining ATD training effectiveness. The reason for this is obvious: Performance in the aircraft, not in the simulator, is the ultimate criterion of operational readiness. There is always a risk that the objectives of training in a simulator are not fully consistent with operational flight requirements, so performance in the aircraft should be examined as a means of validating ATD training. Without having validated ATD training in this manner, it is impossible to assess the magnitude of that risk.

A CAUTION

The evaluations of ATD training effectiveness performed by the units visited during this study were largely intuitive and were conducted by personnel with no formal qualifications for the conduct of such evaluations. Almost no provisions were made, especially after the original introduction of a device, for the systematic collection of performance data that could lead to unequivocal judgments regarding training effectiveness. The major reason for this lack was the fact that personnel available to conduct evaluations seldom had any background in the technical aspects of evaluative research required for valid assessments of ATD training programs.

Since local unit training personnel are often expected to evaluate ATD training effectiveness, it is necessary that these personnel and their commanders be aware when gathering and interpreting data of difficulties that can arise from reliance on relatively informal and loosely controlled studies. Following the guidance provided in this chapter will benefit the quality of ATD training evaluations conducted by unit personnel. This guidance calls attention to many common pitfalls in data collection and interpretation which should be avoided in ATD training evaluation.

This guidance can be helpful to those responsible for evaluating ATD training or for the review of reports of such evaluations. However, within the context of this report, it is not possible to provide a "cookbook" for the design and conduct of a fully scientific and rigorous evaluation. For this reason, it is recommended that technical assistance be sought, wherever possible, when a formal (or even informal) evaluation is in order. The major source of Air Force technical expertise in ATD training evaluation is the Air Force Human Resources Laboratory. Other

sources within the Air Force and elsewhere can be identified through the Laboratory.

PRELIMINARY CONSIDERATIONS

It sometimes is assumed that the training value of an ATD is inherent in the device, i.e., that its training effectiveness can be determined independently of other considerations. This assumption is not valid. Regardless of its design, an ATD must be used to be effective, and it is the manner of its use which largely determines its effectiveness. Thus, any investigation of ATD effectiveness is, in fact, an investigation of the device's effectiveness when used in a specific way. If the manner of its use changes, its effectiveness also may change. While the engineering design may limit the tasks which can be learned in an ATD and, hence, its potential training effectiveness, the way the device is used determines whether that potential will be realized.

Further, ATD training effectiveness is related to the objectives of that training. Effectiveness cannot be determined except with respect to the extent to which training achieves, or facilitates the achievement of, specified performance goals. A given ATD training program can be quite effective with respect to certain training objectives and ineffective--or possibly even have a negative training value--with respect to others. Before the value of any ATD training program can be determined, the intent or objectives of that training must be defined. Effectiveness, then, can only be determined with respect to the extent to which defined training objectives are met.

For these reasons, preparation for the conduct of an evaluation effort is an important--often the major--part of that effort. If the purpose of the assessment is to determine whether training will be more effective with the introduction of a new device, care must be taken to assure that the new device will be used in optimum ways. (Information in Chapters III through VII should be carefully considered when this is being done.) If the purpose of the assessment is to determine whether training with a device is preferred to training without it, it is important that both training programs be optimized with respect to all training resources they employ. Otherwise, the study results may reflect the difference between well and poorly conceived and conducted training programs, not the effectiveness of device training per se.

DESIGN OF ATD TRAINING EFFECTIVENESS STUDIES

A study to determine the effectiveness of a particular ATD training activity must be organized in a manner that will permit valid and repeatable results to be obtained. Usually, a format, or evaluation study design, is adopted that will permit the performance of ATD-trained

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It is important to be able to apply this study design to cases after the control group has been identified and the risk and has been introduced.

particular caution should be exercised in comparing performance under the new program with existing data from the old program. For such a comparison to be valid, the pre-existing data must have been gathered under conditions which would have been applicable to a control group trained concurrently with the test group. Often, it will not be possible to determine whether these conditions were the same, so the results of this design, when applied in an "after the fact" manner, must be viewed cautiously. Particular attention should be paid to whether the two programs used the same or different instructors and whether student characteristics, grading practices, or performance criteria have changed from the old to the new program.

The Uncontrolled Transfer Design

There are circumstances in which a control group cannot be employed and for which suitable control data do not exist. Such circumstances might be dictated by administrative or safety considerations. For example, it might be unacceptable to "penalize" the control group by requiring that it undergo a presumably inferior training program, or when withholding simulator training in certain safety procedures might involve unacceptable risks for the students involved. In other instances, a control group simply may not be feasible; the effectiveness of lunar landing simulators could not be determined by employing a no-simulator training control group of astronauts.

When a control group cannot be employed and suitable control data do not exist, ATD training effectiveness can be established by determining whether students can perform a particular task in the operational aircraft, following its learning in the simulator, without an opportunity to learn that task in the aircraft. Data gathered under this design will be suspect to the extent that it cannot be shown conclusively that the skills involved can be attributed to ATD training. Nevertheless, such data can carry considerable weight, particularly when a task critical to pilot safety is involved and a plausible case can be made that the underlying skills probably are attributable, at least in part, to the ATD training program.

The Backward Transfer Design

The Backward Transfer Design, an ATD evaluation design that examines pilot performance in the simulator instead of in the aircraft, is based upon the transfer of training concept. In a Backward Transfer study, a pilot who already has demonstrated mastery of relevant flight training objectives is "transferred" to the ATD, where he is required to perform tasks corresponding to those he has mastered in flight. If he can perform such tasks to criterion levels without practice in the device, backward transfer is said to have occurred, and this fact is taken as evidence that transfer in the device-to-aircraft sequence, although of unknown quantity, will be positive.

The backward transfer design should be used with caution for at least three reasons: (1) positive results assume (possibly incorrectly) that a suitable training program exists for the ATD; (2) experienced personnel already proficient at operational tasks may have highly generalized skills not possessed by recent training program graduates and may be able to transfer performance to the device because of such general skills rather than skills needed to operate a particular vehicle or perform a particular mission; and (3) the ATD may be suitably designed for the evocation of a particular set of behaviors by skilled performers, but may lack the cues essential to the development of those behaviors by students.

While backward transfer data should not be the sole justification for simulator use or procurement, one would be hesitant to recommend a device which could not be handled by competent pilots. Negative results could be misleading also, however, at least insofar as the value of an ATD during early stages of training is concerned. It is possible for some tasks to be performed in an aircraft by personnel who cannot do so in a device because they use cues not present in the device. The same device, however, may provide other cues which trainees can learn to use to perform those same tasks in the device for subsequent transfer to the operational vehicle. For advanced skills, even successful backward transfer can be difficult to interpret. Because of their overall skill level, experienced aircrews may adapt readily to peculiarities of an ATD when in fact the device is worthless for training new higher order skills that are unique to a given target aircraft.

The ATD Performance Improvement Design

An essential feature of an effective ATD training program is improvement in the performance of trainees as a result of training they receive in the device. If such improvement does not occur in the ATD, there will be little expectation that subsequent operational performance will be improved as a result of device training. Because of this dependency relationship, improvement in performance in the ATD often is cited as evidence that ATD training is effective. This typically is done when circumstances preclude the employment of a transfer design to determine simulator training effectiveness.

Clearly, there are circumstances in which the ATD Performance Improvement Design can provide the best estimate of whether ATD training is effective. The use of the approach exemplified by this design to assess performance that cannot be assessed in flight due to safety or economic considerations was discussed in the introduction to this section of the report. It must be noted, however, that this design does not assure that skills acquired during ATD training will transfer to the aircraft. The design can show that a necessary condition for transfer has been met, but it does not justify the conclusion that the improved performance in the simulator will result in improved operational performance. This model possibly is most useful in a negative way: If

of the training program, and the results of the study will be reported in a separate report.

PERFORMANCE MEASUREMENT

Study designs in which a single measure of performance is used to evaluate training effectiveness are of limited value. In order to obtain a more complete picture, however, measure units must be derived which are directly related to the simulator training objectives. In general, the most reliable method for the measurement of trainee performance is the use of a direct measure of performance in the simulator. The most effective measure of performance should be derived from the simulator and should be directly related to the training objectives.

What to Measure

Any measure of trainee performance can be used to evaluate ATD training effectiveness so long as it is effectively, in well, provides consistent results, and is relevant to the objectives of the training being conducted. Additional performance measurement characteristics which normally must be considered are the feasibility, safety, and cost effectiveness of the procedures employed in the measurement process. The range of measures which can meet these requirements is almost limitless and includes: error scores; time measures reflecting time to criteria, time on target, and task duration; critical events which affect safety such as accidents, control errors, and improper response to a malfunction; frequency and duration of exposure to enemy surveillance; indices of communications content, frequency, and duration; and measures of training effort and efficiency, such as the number of trials to reach criterion performance in the aircraft, the amount of training time saved, or the savings in overall training costs resulting from the ATD training program.

The basic requirement for selecting a performance parameter to measure is its relevance to the objectives of simulator training. For example, an objective might be landing an aircraft, in which case a simple pass/fail measure might be acceptable, i.e., the landing met pre-established criteria or it failed to do so. More specific and detailed objectives and measures of performance would likely be preferable, however. In the case of landing an aircraft, for example, separate measures might be desired which indicate whether the aircraft control, procedural, navigational, and communication tasks performed by the pilot during the five minutes preceding contact with the runway were performed within predetermined tolerances. The specificity of the parameters measured should be determined by the specificity of the training objectives. Since aircrew training programs should be based upon quite specific, systematically derived behavioral objectives, it is to be expected that a well-conducted ATD training effectiveness study will yield multiple, quite specific measures of trainee performance keyed to previously described training objectives.

Some of these "on-line" advantage/disadvantage comparisons, particularly those involving "load" or "stress" levels, have been found to be of limited utility. The "on-line" criteria, such as "feasibility", "safety", or "effectiveness" criteria, which are not simply and not available to the trainee, are, in an alternative, independent manner, including techniques give brief examples of those which can be used. (1) In objective and neutral operation, performance data. These range from a checklist of using an objective or other forms upon which training and performance operator performance on specified parameters as well as performance takes place operationally. Examples of such checklists are the Pilot Performance Description Record developed for the U.S. Army by the Human Resources Research Organization (Green, Smith, and Matfield, 1972) and currently in use in the primary phase of Army UPI at Fort Belvoir, Illinois, and the Illinois Private Pilot Performance Scale, an adaptation of the Army's Record, used in a civilian performance measurement technique. The latter has been used in research on pilot training at the University of Illinois (Lehman, Alvarez, and Danos, 1970).

Descriptive Facts

41.

judgment of the quality of the performance. Command or squadron rating sheets and other evaluative indices of aircrew performance generally are not useful for such purposes. Ratings are by definition subjective and usually are found to incorporate unintended rater bias. Moreover, even if administered in a manner free of bias, they tend to be overly general and do not provide the explicit, systematic information on student performance needed for the detailed analysis of ATD training effectiveness. Daily grade slips currently in use by the Air Force, Army, and Navy also are unsuitable for collecting data describing student performance, because they are designed for evaluative, rather than performance recording, purposes. Recognizing the inadequacy of the forms as they exist, many instructors note instances of performance on the backs of grade slips. However, such notations usually are limited to descriptions of errors and are incomplete and unsystematic, so they would be inadequate for assessing ATD effectiveness.

Standardized Conditions

The data should be recorded under standardized conditions. Measuring instruments should be demonstrably comparable in content and administration across both experimental and control groups. For example, air-to-ground attack performance evaluations should follow the same or comparable routes for both groups, and all special events, such as hostile missile fire and equipment malfunctions, should be evaluated under prescribed conditions. Factors that cannot be standardized, such as daily variations in environmental conditions, should be controlled by assuring that comparable numbers of subjects are evaluated under each variation.

Uniform Criteria

The data should be based upon uniform criteria or standards applied equally to all experimental and control trainees. The specifications of tolerances around correct performances, e.g., airspeed 130 +5 knots at touchdown, must not vary among observers or trainees. The degree of uniformity required can only be obtained through a concerted program of observer training and standardization. The assumption should never be made that uniform data will be obtained without such training, even when competent instructor or check pilots are the observers.

Independent Personnel

The data should be obtained by personnel who are independent of the ATD training activities, and they should have no prior knowledge of an individual trainee's performance during device training. Ideally, they should not even know which trainees are assigned to ATD training and which are assigned to no-ATD control groups. Since significant biases in observer reports tend to be pervasive and are very difficult to correct during data analyses, observers should be obtained from administrative

units as remote as is practical from the unit responsible for conduct of the study so that biases will be less likely.

REPORTING ATD TRAINING EFFECTIVENESS

Except in those rare instances in which the officer conducting the study has sole responsibility for decisions concerning the ATD training activity under study, a report documenting the study findings must be prepared. Often, the format and content of such a report are dictated by organizational requirements. These report requirements typically are developed in connection with test and evaluation procedures for operational equipment rather than for training equipment. Consequently, the resulting reports often tend to be oriented toward equipment performance and the manner in which it is tested rather than toward trainee performance.

In addition to meeting report content and format requirements prescribed by the parent organization, the investigator conducting a simulator training effectiveness study has an implicit obligation to report two kinds of information: (1) description of the manner in which the ATD training effectiveness study was conducted; and (2) the study findings. The purpose for reporting the study findings is obvious. The purpose for describing the study itself is to permit persons not involved in the study to make independent judgments concerning the probable validity of the study findings, based upon how well the study was conceived and conducted. Good descriptions of methodology can also facilitate the conduct of future device evaluation efforts by providing an example to other investigators.

Describing the Study

The description of the study included in the report should include the kinds of information indicated below. The level of descriptive detail appropriate in a particular report is a matter of judgment. That judgment should be made on the basis of a criterion of clearly communicating to an anticipated reader what he might wish to know to support his own assessment of the study findings.

Identification of the ATD Involved

Often, this is a simple matter that can be accomplished in part through reference to design documents or manufacturers' descriptions. In the case of unique, locally fabricated or modified devices, more information may be required.

Description of the Manner in Which the ATD was Used

This description should identify the principal features of the device training program; reference formal course description materials

being "suffered" for the "benefit" of "multitude" (10:1-2).

Deficiencies in Formal ATD Effectiveness Studies

The most critical deficiencies that were identified in formal studies of ATD effectiveness arose from (1) the inability of test personnel to exercise necessary experimental control during studies in operational training environments; (2) inadequate support for ATD training activities; and (3) methodological problems that limited the studies and confounded interpretation of their results. These deficiencies are relatively common and are worth noting here.

Inability to Exercise Control

ATDs and other training resources are sometimes made available for research or evaluation with the restriction that these activities not interfere with ongoing operations and training. However, in order to carry out these studies, it is usually necessary to specify the amount, sequence, and type of training a subject is to receive. Adjustments often must be made in existing training and operational schedules for these requirements to be met. A common problem reported during the present project was the deviation from planned study schedules that invalidated the ATD comparisons that were to be made. These deviations were usually attributed to operational personnel who did not understand or give priority to the studies. Other related problems that were reported included biased assignment of subjects to comparison groups, unscheduled changes in instrumental personnel, and lack of cooperation from management and operational personnel in the collection of data.

Inadequate Support

Another major source of deficiencies was the failure in many programs to provide adequate support for the ATDs during the study. For example, ATDs were used that were new and not yet ready for training, or they were not properly maintained. Also, instructors were not trained adequately. The results of ATD effectiveness evaluations conducted with such degraded support are likely to underestimate the potential effectiveness of ATD training and thus lead to under-utilization of the devices. Assessments of ATD training effectiveness should only be conducted after personnel responsible for the assessments are convinced that the studies will be adequately supported.

Methodological Deficiencies

Serious methodological flaws are common in published studies of training effectiveness, many of which deal with flight simulation. The problems concern deliberate design and analytic procedures that render the reported statistical tests meaningless. The more common flaws included matching test subjects to compensate for small numbers of subjects when matching was inappropriate to the statistics employed, using inappropriate criteria for accepting (or rejecting) a study finding, uncritical acceptance of the conclusions of other researchers who performed related studies without examining their data and analytic

methods, incomplete reporting of experimental procedures, and just plain carelessness in data handling, including simple arithmetic errors. Uncritical acceptance of the reported findings of studies of ATD effectiveness could result in an inaccurate impression of the worth of the devices in question.

Two other methodological problems noted during the present project were also identified in the previously cited review by Diehl and Ryan (1977). One problem is the fact that student performance criteria used to assess the effectiveness of ATD training are usually defined in subjective, ambiguous, nonstandard terms, often involving poorly defined measures. The other problem is that training requirements analyses, which are necessary (but not sufficient) to establish the validity of training requirements, often are not performed prior to conducting the evaluation. Problems such as these make study results uninterpretable even when there are no design and analytic problems to contend with.

Because they are not trained to assess the technical adequacy of the methodologies employed in the design, conduct, and analysis of these studies, senior command personnel often are not aware of deficiencies in many of the formal ATD assessment studies that have been conducted and reported. Furthermore, inadequacies in the managerial control and support provided to the studies, inadequacies that often eviscerated even the well-designed studies, usually are not reported or are viewed as being justified by operational necessities, an explanation that appears to satisfy many personnel but does nothing to salvage uninterpretable data.

There is likely to be an increasing number of ATD training assessment studies in the future. If the methodologies employed and the managerial control and support of the assessments are not improved, then these studies may be not only useless, but misleading and consequently damaging to future ATD utilization.

Informal Studies of ATD Training Effectiveness

Not all ATD training effectiveness assessments are conducted and reported formally. Even when the results of formal studies are not available, most of the personnel involved in ATD training could cite some kind of "evidence" that their training was effective. For example, Operational Readiness Inspections or other Inspector General-type unit evaluations that included analyses of unit ATD utilization practices were cited in a few instances to support existing ATD training programs.

It was found during interviews that there have been numerous informal and generally unsystematic studies of ATD effectiveness, usually conducted by unit personnel with no formal training or other indicated qualifications for undertaking such a task. Many of these studies have been imaginative and resourceful, but they often suffered from various

1. The first part of the report is a general statement of the purpose of the study and the objectives of the investigation.

2. The second part of the report is a description of the methods used in the study and the results of the investigation.

3. The third part of the report is a discussion of the results of the study and the conclusions drawn from the investigation.

4. The fourth part of the report is a summary of the findings of the study and the recommendations for further research.

5. The fifth part of the report is a list of references and a list of figures and tables.

6. The sixth part of the report is a list of appendices and a list of footnotes.

7. The seventh part of the report is a list of acknowledgments and a list of dedications.

8. The eighth part of the report is a list of references and a list of figures and tables.

9. The ninth part of the report is a list of appendices and a list of footnotes.

10. The tenth part of the report is a list of acknowledgments and a list of dedications.

11. The eleventh part of the report is a list of references and a list of figures and tables.

12. The twelfth part of the report is a list of appendices and a list of footnotes.

13. The thirteenth part of the report is a list of acknowledgments and a list of dedications.

14. The fourteenth part of the report is a list of references and a list of figures and tables.

15. The fifteenth part of the report is a list of appendices and a list of footnotes.

16. The sixteenth part of the report is a list of acknowledgments and a list of dedications.

17. The seventeenth part of the report is a list of references and a list of figures and tables.

18. The eighteenth part of the report is a list of appendices and a list of footnotes.

19. The nineteenth part of the report is a list of acknowledgments and a list of dedications.

20. The twentieth part of the report is a list of references and a list of figures and tables.

validity of the study findings. A study report should include, as a minimum, an identification of the ATD involved, description of the manner in which it was used, identification of the trainees, a description of the study design, a description of the performance measurement and analytic procedures, and a detailed description of the study results.

CHAPTER IX

MAINTAINING ATD TRAINING EFFECTIVENESS

Chapters III through VII of this report are concerned with the development and management of effective ATD training. Chapter VIII discussed the need to assess ATD training programs after they have been developed in order to verify that they are effective. This final chapter addresses the need to monitor ongoing ATD training and training support to assure that the level of training effectiveness established through the previous efforts is maintained over time.

FACTORS IMPACTING EFFECTIVENESS

Many kinds of factors can impact ATD training by reducing its effectiveness. Some are transitory, such as the temporary disruptions that occur when key instructors are reassigned or when the device is out of service undergoing modification. Others persist, and, if not attended to, will adversely affect training. These latter problems are of four principal types: (1) changes in training requirements that invalidate existing training programs; (2) modifications to the aircraft that reduce its correspondence to the ATD; (3) inadequate maintenance support which renders portions of ATDs inoperative; and (4) deterioration in the device training program itself. Each of these factors is discussed below.

Modified Training Requirements

It is virtually inevitable that changes will occur from time to time in the requirements underlying any simulator training program. These changes may occur due to introduction of new training equipment, development of new tactics, or safety related concerns. When a new part-task trainer is acquired, for example, some training previously conducted in a flight simulator should be shifted to it, permitting the simulator to be used for additional training. When mission requirements or tactics change because there is a need to nullify improved enemy air defenses, training must quickly accommodate this need. When information from accident investigations requires changes in the way aircrews perform tasks, established training practices must be revised. There is almost a limitless number of changes that can take place. All such changes require that ATD training be modified in some manner in order for a previously established level of effectiveness to be maintained.

For the most part, it was found that the need to adjust or modify ATD training following changes in training requirements was recognized by the personnel responsible for ATD training. In all cases at the units visited during the present survey, action had been completed or was reported to be underway to adjust ATD training as necessary to accommodate all changes known to have occurred in ATD training

In some aircraft, changes to the programming of on-board computer systems are matters of particular concern and frustration to ATD users. Unless modifications are made in the ATDs to reflect the aircraft hardware and software changes, the effectiveness of the device training programs may be impaired.

Nearly all of the ATDs surveyed during the present project needed updating, although the need appeared greatest with devices simulating the newer aircraft. The modifications that were needed to update the ATDs to the current configuration of the aircraft they represented included the repositioning of existing cockpit displays or controls, changing the simulated performance characteristics of the aircraft's engines, simulating a different radar or EW control panel, and reprogramming the simulation of the on-board computer system. In some instances, lack of the required ATD modifications was probably of minor training transfer consequence and could be compensated to a large extent by calling the students' attention to the ATD-aircraft discrepancy as described in Chapter IV. In other instances, the consequences were significant. In one, modifications had been made to an aircraft's weapons system computer that resulted in changes in the sequence of procedural tasks performed in the cockpit under high workload condition, and negative transfer to the target aircraft almost surely resulted.

The failure to modify ATDs promptly when aircraft are modified is a major problem. Delays in effecting important modifications to ATDs were counted in years at some units. In some instances, no updating of the device was even planned, and training objectives that had been allocated to ATDs prior to aircraft modification had been reallocated to aircraft.

There are a number of reasons for the existence of this problem. An obvious one is the need for funds to accomplish the device modification. In most cases, funds for modifications made to aircraft and to ATDs originate from different budget sources, so the availability of funds for the former does not assure funds for the latter. One exception to this situation was noted during the survey, however, that apparently solved the problem: One military service required that funding for all projects that involved aircraft modifications cover corresponding modifications to the simulator for that aircraft.

A second reason involved the separation of responsibility for modifying the two vehicles. The usual situation is that one agency is responsible for modifying aircraft, while another for modifying ATDs--and neither of these has responsibility for use of the vehicle for training. As a consequence, there appears to be inadequate communication between the two, and little or no effort to coordinate the modifications was noted. In fact, efforts to modify the ATD usually do not begin until sometime after the aircraft modifications have been completed and tested.

Several other reasons were given by the personnel interviewed for delays in obtaining ATD modifications. These reasons included inadequate

documentation that could be used by government personnel to make in-house device modifications, ATD hardware and software designs that were difficult to modify, and constraints associated with the contracting process ("red tape").

In view of the predictability of effects of aircraft modifications, and the inherent flexibility of the performance of digital computer-controlled ATDs, there is no need for lengthy delays in modifying simulators to reflect aircraft changes. Clearly, however, such delays are inherent in present approaches to the management of requirements for ATD modifications. It is believed that the maintenance of ATD training effectiveness could be improved if more attention were directed to expediting critical modifications to ATDs.

Inadequate Device Maintenance

An ATD must be working correctly if it is to be used effectively. Therefore, effective maintenance support is requisite to effective ATD utilization over an extended period. As was indicated in Chapter VII, very few instances of lost training periods noted during the survey were attributable to inadequate maintenance support. Those that were identified were associated with old and possibly worn out devices or new devices that were still undergoing debugging activities. No examples were reported during the project interviews in which adequately trained in-house or contract maintenance personnel were unavailable within reasonable time periods when breakdown occurred. In fact, the quality of available maintenance support, in combination with the reliability of current generation flight simulators, typically resulted in an average loss of less than a single scheduled training period per week.

Unfortunately, the above statements concerning the availability of ATDs for training, while correct, tend to be misleading. There were many instances when ATDs were used with a significant subsystem inoperative due to unavailability of parts. Further, it was not unusual to find that the ATD subsystem in question had been "down for parts" for extended periods. Motion and visual subsystems were the ones most commonly needing parts, but problems existed with other simulator subsystems as well. For example, cockpit instruments were sometimes inoperative for want of replacement spares, and one device reportedly had been without a part for its Record/Playback instructional feature literally for years.

When needed component spares are not readily available or when any other aspect of maintenance reduces the availability of an ATD subsystem for training, training effectiveness is likely to be reduced. Many times, the device continues to be used--and effectively, too, for training that is not dependent upon the down subsystem--but its overall contribution to aircrew training is likely degraded beyond that reflected in the ATD utilization rate data.

It should be noted that efforts are being made by ATD procurement and logistic agencies to increase the quality of maintenance support, even beyond the high levels noted during the present project, through the conduct of product improvement programs and the establishment of centralized ATD maintenance and logistic systems. These efforts are concentrating particularly on device subsystems with relatively high maintenance personnel support requirements and problems of long lead time for parts replacement. An effort by the Naval Training Equipment Center to analyze maintenance problems associated with ATD motion systems is noteworthy in that regard.

Several mechanisms already exist for monitoring the maintenance status of ATDs. Maintenance logs reflect the status of each device on a continuing basis and document any deficiencies in system and subsystem operation. In addition, ATD instructors and students are responsible for reporting device deficiencies by entering the information in a "flight log" maintained for that purpose. Both the maintenance and the flight logs can serve a useful purpose in determining whether training objectives allocated to ATDs can continue to be met or whether ATD degradation will require that those objectives be allocated elsewhere.

It is the usual practice at all the units surveyed for the assigned maintenance personnel to operate the simulator daily for the purpose of assessing whether its responses to control manipulations are consistent with specified performance data. All of the more sophisticated ATDs employ a computer to assist these personnel in making various diagnostic checks to determine whether maintenance is needed. Another useful practice frequently followed is to have an aircrewman operate the device periodically to determine whether its flight responses are comparable to those of the aircraft simulated. Each of these checks can serve a useful purpose by alerting ATD training personnel when the effectiveness of their training programs may be below par.

The Air Force has taken steps to expand its procedures for verifying that ATDs continue to be maintained adequately. A "Simulator Certification" program is currently under development that in all likelihood will increase the effectiveness of these monitoring efforts. Information from that program should be monitored by training personnel so that, as ATD deficiencies are detected, adjustments can be made to assure continued overall training program effectiveness, e.g., by reallocating to the aircraft those training objectives which can no longer be met through ATD training because of detected deficiencies in the device.

Training Program Deterioration

The fourth type of factor that can reduce the effectiveness of ATD training involves the manner in which the device is used, i.e., the ATD training program itself. Independently of whether changes attributable to the three types of factors discussed above have occurred, the quality

of the training itself can deteriorate. When this occurs, intended training objectives may no longer be met. For example, if ATD training begins to concentrate upon actions that cannot be performed in the aircraft, key instruction and guidance is no longer employed during pre-training session briefings, or instructional features cease to be used effectively, the necessary skills may not be learned within the time available for ATD training.

Changed training practices such as these, when they occur, can be attributed to many causes, e.g., reassignment of experienced instructors, variation in the quality of student input, changed attitudes toward ATD training, and lessened management attention as ATD newness or novelty wears off. A training program previously assessed as effective should not be expected to retain its effectiveness as these changes occur.

Gradual, or possibly even abrupt, changes in ATD training programs such as those cited may not be obvious, particularly to personnel in day-to-day contact with the training. In this respect, these kinds of changes are unlike the more obvious changes in training requirements, aircraft configuration, and device availability discussed earlier. Even the most skilled analysts would have difficulty monitoring instructor experience, student quality, student and instructor attitudes, etc., to determine whether a change had occurred that would likely impact ATD training practices. Nevertheless, monitoring of such factors was found to be the principal means for assessing and maintaining consistency in the conduct of ATD training programs among the units surveyed.

The monitoring efforts noted were all informal, and most were unsystematic. They consisted of the following: (1) aperiodic discussions among ATD instructors of problems encountered during the conduct of training; (2) periodic and aperiodic "standardization" meetings in which a section chief or other senior instructor discussed with the ATD instructors syllabus requirements, instructional techniques, and scheduling problems; (3) aperiodic observation of ATD instruction in progress by the same individuals; (4) aperiodic syllabus review by ISD team representatives or other personnel outside the training unit; and (5) continuing analysis of student grade slips and program records by a variety of personnel interested in training effectiveness. These efforts, which varied in format and frequency from unit to unit, must be credited for the levels of ATD training effectiveness currently being maintained.

At best, however, efforts such as these can be only partially satisfactory. While they will detect most major anomalies in the way in which training is being conducted, they are largely insensitive to gradual changes. In addition, these efforts cannot reliably detect losses in training effectiveness that may result from deliberate changes in course content, instructional content, or scheduling procedures that were made with the expectations that the program would benefit instead.

The absence of a reliable mechanism for systematically monitoring ATD training effectiveness on a continuing basis was judged to be an important deficiency in the management of the ATD training surveyed during the present project. Regardless of the best of intentions, lacking such a monitoring mechanism, some deterioration in effectiveness should be expected to occur over time in any ATD training program. The consequence is likely to be a need to expand other elements of the overall flight training system to compensate for the loss in ATD training effectiveness.

It should be noted that ISD procedures, as defined in AFP 50-58 and AFM 50-2, explicitly require the monitoring of all ISD-developed training. None of the ATD training programs surveyed during the current project had been developed as a part of a comprehensive effort to "ISD" an entire flight training program, although ISD teams had had some input to most of these programs. In time, ISD efforts will include monitoring all ongoing ATD training. AFM 50-2 and other documents defining such requirements do not specify how the monitoring is to be accomplished, however.

The following section of this report describes an approach to monitoring ATD training that would provide early detection of deterioration in training or loss in its effectiveness. With the information such an approach could provide, deficiencies could be detected and corrected early, and ATD training effectiveness could be more easily maintained.

MONITORING THE ATD TRAINING PROCESS

In Chapter VIII, an emphasis was placed upon the measurement of student performance as a means of assessing ATD training program effectiveness. That is, the effectiveness of ATD training should be determined by measuring the qualities of the product of that process. The product of training, of course, is the student at the end of or subsequent to his training in the device.

Measuring training product quality is analogous to determining the effectiveness of a manufacturing process by measuring the qualities of the products produced. In fact, the product quality control systems established by industrial manufacturers provide a useful model for the establishment of a quality control system to monitor the effectiveness of aircrew training programs involving ATDs.

The general concept of a quality control system for a training program has been discussed by Smith (1965). An extensive application of the concept to military flight training has been described by Duffy and Colgan (1963). These writers outline five general requirements for an effective training quality control system:

- A detailed statement of training objectives based on job requirements
- Accurate and appropriate performance measures
- Effective communication concerning performance of students on the tests
- Effective procedures for corrective action, if necessary
- Supervisory support

Training Objectives

The assessment of training program effectiveness should be conducted in terms of objective standards that define the achievement of course objectives. This requirement was discussed in Chapter VIII. Since the present concern is the maintenance of an established level of performance, the applicable standards are the same as those employed in the study of ATD training effectiveness that presumably will previously have been conducted.

There are, however, additional concerns regarding an ongoing monitoring system that do not apply when the effectiveness of the training program is being assessed initially. Because the initial assessment study is a one-time activity, it may be feasible to employ comprehensive performance monitoring and data analysis techniques or procedures that would be too costly to consider on a continuing basis. Therefore, it may not be practical to continue to assess student performance with respect to all of the training objectives assessed originally.

Care must be taken, however, to assure that the objectives selected to be monitored constitute an adequate sample of the performance of interest. There could be a problem in that an originally adequate sample may not remain so month after month. There would be a tendency during training to increase emphasis on those objectives that are evaluated regularly, and possibly to neglect those that are never monitored. This problem could be prevented by periodically replacing some of the objectives sampled on one occasion with others, so that over time most if not all significant skills will have been sampled and evaluated.

The adequacy of a sample at a given time must be left to the expert judgment of the personnel involved. However, they must guard against selecting objectives on the basis of convenience or ease of measurement. Confidence in the adequacy of the objectives selected with respect to overall training program goals is a better basis for their selection.

Performance Measurement

Measurement of product quality is the source of the feedback about student proficiency that is the cornerstone of a training quality control system. Because this information defines the need for corrective action,

it is critically important that it be relevant and objective. Rating scales and other evaluative indices, e.g., daily flight grade slips, do not provide the quality of information needed for quality control purposes. How to obtain measures that are relevant and objective is discussed in Chapter VIII.

In Chapter VIII, it was pointed out that ATD training effectiveness ideally should be determined by measuring student performance in the target vehicle after the ATD training has been completed. The same guidance holds with respect to measurement for quality control purposes. However, after a particular ATD training program has been validated through a transfer of training study, it may then be possible to measure student performance in the ATD at the end of training (or at times during training corresponding to the times at which performance was measured during the earlier assessment study), and to use those data for quality control purposes. Such uses of measures of ATD performance would be justified if the ATD performances selected for evaluation had been shown in the earlier evaluative research to correlate highly with corresponding performances in the aircraft. In such cases, the use of the automatic performance measurement capabilities designed into some ATDs would be possible.

Communication

Data obtained by measuring student proficiency must be analyzed and summarized in some manner so that the strengths and weaknesses of the training program can be identified and communicated to management. The information to be extracted from these data relate to trends, since deterioration in student quality can be a slow process that will be apparent only over a period of time. Unsatisfactory performance of individual students will be immediately obvious, of course, but the performance of an individual reveals little about the quality of the training program.

Clear, succinct, and meaningful summaries of performance data must be communicated to appropriate instructional and managerial personnel so that they can determine whether a training quality maintenance problem exists. Judgments of the adequacy of the training program should also be communicated, but those judgments should be based on data, not substituted for data. The data summaries and accompanying judgments also should provide a basis for decisions concerning corrective action, when such is required.

Corrective Action

Quality control is effective only when corrective action can be taken quickly. Such action is best achieved through the judgment and skill of experienced training program development personnel and highly competent managers of ATD training programs. The action taken must reflect a thorough understanding of the performance data and the

relationship between deficiencies in performance reflected in those data and the aspect of the training program changed.

As with changes made in ATD training in response to modified training requirements, the corrective actions taken should be determined through a systematic analysis which takes into consideration all elements of the instructional system, and the rationale for the existing design of these elements. Rather than short-term "patches" to solve a specific problem, the changes made should be part of the continuing systematic development of the instructional system. Additionally, all corrective actions taken in training should be formally documented to promote the consistent implementations of the changes, and to make the changes and the reasons for them available for future analysis.

The continued effectiveness of ATD training is dependent upon the continued application of corrective action when required. Communication of information about product quality to management is a continuing proposition. The system must provide for regular analyses of performance data and periodic communication of those data to management.

Management Support

Strong support from all levels of management is essential to make the quality control system work. To secure and maintain this support, everyone involved must have a clear idea of the purpose of the system and the rationale for its various parts. Key management personnel must understand what the program can do for them in terms of maintaining overall mission readiness, and they must be convinced of the program's utility.

In addition, responsibility for day-to-day management of the system must be focused. Someone must be in charge, and that individual must have authority to schedule performance tests, to select and train examiners, and to call performance deficiencies to the attention of those in positions to take necessary corrective action. Constructive policies and procedures for corrective actions should be established ahead of time. They should focus on correcting deficiencies, not singling out individuals to blame. In fact, if punitive actions are taken against instructors and other training personnel, it is likely that the quality control process itself will suffer.

Reports by Duffy and Colgan (1963), Smith (1965), and Caro (1968) provide guidance for managers of flight training quality control systems that applies to all these issues, and that guidance is readily adaptable to ATD training situations.

SUMMARY

This final chapter addressed the need to monitor ongoing ATD training and training support to assure that the level of training effectiveness established through previous efforts is maintained over time. Information was presented concerning factors that can act to reduce the effectiveness of ongoing ATD training, and mechanisms for maintaining training effectiveness were discussed. This information is summarized below.

- ATD training should be revised to reflect modifications in the requirements underlying that training. Since changes occur from time to time in the requirements underlying any ATD training program, each training organization should have a mechanism for assuring the systematic revision of ATD training to accommodate these changes.

- All adjustments made in ATD training to accommodate modified training requirements should be documented. The absence of up-to-date ATD training objectives and course documents tends to affect standardization of training adversely.

- When modifications to an aircraft reduce its correspondence to an ATD, the device should be modified expeditiously. In view of the predictability of effects of aircraft modification, and the inherent flexibility of the performance of digital computer-controlled ATDs, there is no need for lengthy delays to occur in modifying the simulator to reflect aircraft changes.

- Funding for all projects that involve aircraft modifications should cover corresponding modifications to the ATDs for that aircraft. Integration of funding ensures that resources are available for the ATD update programs.

- ATDs should be maintained so that all ATD subsystems function according to specifications, and thus not restrict training. When inadequate maintenance reduces the availability of an ATD subsystem for training, the overall contribution of the ATD to aircrew training is likely to be degraded beyond that reflected in utilization rate data.

- The maintenance status of the ATD should be monitored routinely. The device should be inspected frequently by qualified aircrew personnel within the organization as well as by maintenance personnel.

- When deficiencies in ATD subsystems are detected, adjustments should be made to assure continued overall training program effectiveness. The device can continue to be used for training that is not dependent on a down subsystem, but ATD training objectives that can no longer be met through ATD training because of detected subsystem deficiencies should be reallocated to the aircraft.

- The quality of ATD training should not be allowed to deteriorate over time. Some factors that can be disruptive of ATD training (e.g., turnover of personnel) are inherent in operational training organizations, and their occurrence can be anticipated. These factors should be recognized, and steps should be taken to prevent any disruptive effects on ATD training.

- The effectiveness of ATD training should be monitored routinely. The actual effect of gradual, or possibly even abrupt, changes in factors that can disrupt ATD training may not always be obvious to personnel involved in that training. The best way to determine whether a training program is continuing to be effective is to assess, on a routine basis, the proficiency of the graduates of that program.

- Assessments of ATD training effectiveness should be based on detailed statements of training objectives. An effective ATD training quality control program is dependent upon the existence of suitable objectives for that training.

- The objectives selected to be monitored should constitute an adequate sample of the performance expected of the graduate. It may not be practical or cost effective to assess student performance routinely with respect to all of the training objectives. Nevertheless, by selecting samples of objectives that are representative of all training program goals and by varying the constitution of the samples over time, adequacy of the samples used for monitoring can be assured.

- Relevant and objective performance measures should be employed to obtain data for quality control purposes. Rating scales and other evaluative indices (e.g., daily flight grade slips) do not provide the quality of information needed for quality control purposes.

- Clear, succinct, meaningful summaries of performance data should be communicated to appropriate instructional and managerial personnel. These data summaries and accompanying judgments as to the adequacy of training provide the basis for the identification of training problems and for decisions concerning corrective actions.

- Action to correct training problems should be taken quickly. Quality control is most effective when corrective action is taken quickly.

- Corrective action to remedy deficiencies in ATD training should be based on the systematic analysis of deficiencies in relation to all elements of the instructional system. Adjustments made in ATD training to correct deficiencies should harmonize with the overall design of the aircrew training program.

- Management should provide adequate support to the quality control system. To secure and maintain this support, everyone involved must have a clear idea of the purpose of the system, its utility, and the rationale for its various parts. Additionally, someone must be in charge and responsible for ensuring that all of the quality control functions are executed properly.

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APPENDIX A
STRES INTERVIEW GUIDE FOR SIMULATOR UTILIZATION

A. SIMULATOR TRAINING OBJECTIVES

1. Determine origin and methods of development of simulator training objectives statements.
2. Identify and summarize specific training objectives which are trained only in the simulator. (Determine why)
3. Identify and summarize specific training objectives which are trained only in the aircraft. (Determine why)
4. Identify and summarize specific training objectives which are trained in both the aircraft and simulator.
5. Locate personnel with direct knowledge of the following:
 - a. Through what process were training objectives allocated to simulator vs. other media?
 - b. What role did specific simulator design features play in this process?
 - c. How was engineering fidelity taken into consideration in this process?
 - d. What other considerations were involved in allocating objectives to simulator training?
6. Describe recent changes in the objectives allocated to simulator training and indicate reasons.
7. Identify specific simulator design changes (e.g., updates of outmoded equipment or addition of new capabilities) that would permit additional objectives to be trained and describe reasons.
8. To what extent did training objectives influence initial simulator design or subsequent device modification?
9. Identify specific additional training objectives that could be met through simulator training if additional training time were available.
10. What were the qualifications (e.g., education and experience other than in aviation) of the personnel who allocated objectives to simulators?
11. Surveyor's assessment:
 - a. Validity of information obtained
 - b. Rigor of application of systematic method to objective allocation
 - c. Relevance of objectives to device design
 - d. Relevance of objectives to training programs
 - e. Other

B. SIMULATOR TRAINING METHODS AND TECHNIQUES

1. Are there any personnel involved in the instructional process who are not flight rated?
2. Are peer and/or self-instructional concepts employed?
3. Is train-to-proficiency concept employed?
4. Does training include dynamic observation?
5. Is there firm continuity in instructional staff
 - a. Within simulator training?
 - b. Across simulator/other devices/aircraft?

6. How are instructional events sequenced
 - a. Within simulator training?
 - b. Across simulator/other devices/aircraft?
7. How is training in the simulator procedurally or methodologically different from training in the aircraft?
 - a. Individual
 - b. Crew
8. Identify and characterize major elements of any lesson guides, plans or other material specifically devoted to the instruction of students in the simulator.
9. Describe uses of simulators for proficiency certification (e.g., annual instrument checks) and other proficiency assessment programs (e.g., operational readiness evaluations)
10. Characterize the impact of use of simulator instructional features on simulator utilization.
 - a. Identify commonly used features.
 - b. Describe perceived impact of use of each.
11. Through what processes are individual student training periods scheduled? What are considerations?
12. Determine the extent to which aircrew training (e.g., pilot, weapon system operator) is conducted simultaneously in multiman or linked simulators.
13. Describe innovative uses of simulator/simulator features.
14. Describe perceived problem/deficiencies in simulator training methods.
15. How is simulator training quality control maintained?
16. Is the simulator instructional process monitored? How?
17. Performance measurement (impact on utilization).
 - a. How is performance measured (instrumentation and procedures)?
 - b. How are performance criteria established (normative or criterion-referenced)?
 - c. Satisfaction of instructors and students with performance measurement.
 - d. Impact of evaluation of performance in the simulator.
 - e. Surveyor's assessment of the adequacy of evaluation in the simulator.
18. Describe organizational/command relationships between simulator training and other training activities.
19. Identify simulator training management factors that influence training personnel attitudes.
20. Characterize the nature of recent significant revisions of the training program which modified the use of the simulator.
 - a. Identify reasons for the revisions.
 - b. Identify the sources of requirements for these revisions.
 - c. Identify the agency or individuals who actually developed the revised syllabi and training materials.
21. Surveyor's assessment
 - a. Validity of information reported
 - b. Utilization innovations
 - c. Problems noted

- d. Implications for other programs
- e. Factors constraining effective training
- f. Effects of command/unit utilization philosophy
- g. Other

C. SIMULATION TRAINING EFFECTIVENESS

1. Formal tests and demonstration of effectiveness
 - a. Documentation (obtain copies)
 - (1) Published reports
 - (a) Title
 - (b) Authors
 - (c) Date
 - (d) Publishing organization
 - (e) Other identifying information
 - (2) Informal reports
 - (a) Identifying description
 - (b) Responsible organization/individuals
 - (c) Date
 - (d) Other identifying information
 - b. Study approach
 - (1) Experimental design
 - (2) Subjects
 - (3) Independent variables
 - (4) Dependent variables
 - (5) How was performance measured
 - c. Results
 - d. Surveyor's comments
2. Informal tests and demonstrations of effectiveness
 - a. Procedures employed
 - b. Independent variables considered
 - c. Dependent variables investigated
 - d. Findings
 - e. Responsible organization/individuals
 - f. Surveyor's assessment
 - (1) Rigor of study efforts
 - (2) Validity of findings
 - (3) Generality of results
3. Other evidence of effectiveness
4. Effectiveness assumptions underlying simulator use
 - a. Assumptions
 - b. Bases for assumptions
5. Benefits of simulator training (documented?)
 - a. Aircrew performance
 - b. Safety
 - c. Economic
 - d. Other

6. Effects of simulator effectiveness evidence
 - a. Subsequent simulator design/modification
 - b. Training personnel attitudes/expectations
 - d. Regulation/procedures
 - e. Other
7. Surveyor's assessments
 - a. Simulator effectiveness
 - b. Worth of simulator ownership
 - c. Validity of user perceptions
 - d. Problems noted
 - e. Implications for each program
 - f. Other

D. SIMULATOR DEVELOPMENT AND INTRODUCTION

1. Describe source(s) of following information.
2. Initial simulator RFT date.
3. Describe user involvement in:
 - a. ROC preparation
 - b. Simulator design
 - c. Simulator development (identify developer)
 - (1) Design review conferences
 - (2) Mock-up
 - (3) In-plant testing/checkout
 - (4) Other
 - d. On-site testing
 - e. Initial training program development
 - f. Subsequent modifications
4. Describe factory training provided and summarize perceived adequacy of this training.
 - a. Instructors
 - b. Operators
 - c. Maintenance personnel
5. Characterize user attitudes regarding device's training values (related to changes in utilization of the simulator.)
 - a. During development
 - b. During on-site testing
 - c. At RFT
 - d. One year after RFT
6. Describe specific efforts designed to influence user attitudes/expectations, their results.
7. Characterize user's satisfaction with the development and introduction processes.
8. Characterize user's satisfaction with responsiveness and adequacy of simulator modification procedures.
9. Describe user recommendations for modified processes and identify reasons for recommendations.

10. Surveyor's assessment.
 - a. Validity of information received
 - b. Problems noted
 - c. Implications for future developments
 - d. Other

E. SIMULATOR UTILIZATION RATES

1. Simulator training schedules
 - a. Total no. hrs. of simulator training per individual
 - b. Total no. hrs. of inflight training per individual
 - c. Hours/day, days/week, weeks/year
 - d. Make-up schedules
 - e. Duration of individual training sessions; identify reasons for selected durations
 - f. How coordinated with trainee's other activities
2. Factors influencing utilization rates
 - a. Regulations and "guidance"
 - b. Training syllabus requirements
 - c. Schedule considerations
 - d. Student flow
 - e. Adequacy of maintenance support
 - f. Attitudes of personnel
 - g. Other
3. Surveyor's assessment
 - a. Validity of numbers reported
 - b. Productivity of training time reported
 - c. Adequacy of maintenance support
 - d. Role of regulations and "guidance"
 - e. Reasonableness of schedule factors
 - f. Problems noted
 - g. Implications for other programs
 - h. Other

F. SIMULATOR TRAINING PERSONNEL

1. Instructor (A/C function: _____)
 - a. Typical instructor characteristics
 - (1) Rank
 - (2) Flight experience
 - (a) Total hours
 - (b) Hours in A/C type
 - (c) Hours in combat
 - (d) Other relevant experience
 - (3) Instructing experience
 - (a) Prior flight
 - (b) Prior flight support
 - (c) Other
 - b. Selection criteria/procedures

- c. Hours worked/week
 - (1) Student training activities
 - (2) Unrelated other duties
- d. Instructor/trainee ratio
- e. Perceived effects of assignment on career
- f. Role in simulator/program development
- g. Perceived value of major simulator features
 - (1) Motion
 - (2) Visual
 - (3) Sensor
 - (4) Navigation
 - (5) Crew position links
 - (6) Weapons delivery
 - (7) Malfunctions
 - (8) Other
- h. Perceived adequacy of maintenance support
- i. Characterize attitudes toward simulators
- j. What factors appear to influence those attitudes?
- 2. Instructor training
 - a. A/C-related
 - b. Simulator-related
 - (1) Identify and characterize major elements of any courses, training materials, or OJT supervision designed to:
 - (a) help the instructor in the operation of the simulator;
 - (b) make the instructors aware of the instructional features and training potential of the simulator;
 - (c) help the instructor plan his instruction in the simulator;
 - (d) other
 - (2) Identify and characterize any instructor job aids.
 - c. Other
 - e. Perceived worth/relevance of training received
- 3. Trainees (A/C function: _____)
 - a. Describe selection criteria/procedures
 - b. Input sources
 - c. Typical prior operational experiences
 - (1) Years in service and rank
 - (2) Total hours
 - (3) Hours in A/C type
 - (4) Hours in combat
 - (5) Other relevant experience
 - d. Perceived value of simulator training
 - e. Perceived value of major simulator features
 - (1) Motion
 - (2) Visual
 - (3) Sensor
 - (4) Navigation
 - (5) Crew position links

- (6) Weapons delivery
 - (7) Malfunctions
 - (8) Other
- 4. Training personnel suggestions for change (identify reasons for suggestions)
 - a. Simulator design
 - b. Training program content, sequence, completeness, etc.
 - c. Training schedules
 - d. Other
- 5. Surveyor's assessment
 - a. Instructor status/morale
 - b. Adequacy of instructor training
 - c. Validity of instructor/trainee assessments
 - d. Problems noted
 - e. Implications for other programs
 - f. Other

GLOSSARY OF TERMS

GLOSSARY OF TERMS

- ATD - aircrew training device.
- AUGMENTED FEEDBACK - intrinsic feedback that has been enhanced, usually during training, to make it more evident.
- CCT - combat crew training.
- CPT - cockpit procedures trainer.
- CT - continuation training: training conducted routinely in operational squadrons or proficiency training conducted periodically.
- COGNITIVE PROCESSES - actions that involve the mental processing of information; perceptions and language are typically involved, but cognition may be either consciously or unconsciously directed.
- COST EFFECTIVENESS/EFFICIENCY - the extent to which objectives (e.g., training goals) are achieved with minimal financial cost.
- CUE - the informational content of one or more stimuli that signifies the status of a system, what actions should be taken, or the outcome of actions or events (feedback).
- CUE DEVELOPMENT - the process of learning to interpret stimuli, i.e., to derive pertinent information from conditions and events as guides for actions.
- DISCRIMINATION - the recognition that one cue or response differs significantly from a similar cue or response in terms of its nature, meaning, or effects. Discriminations are the building blocks of any motor or cognitive skill.
- FEEDBACK - information regarding the adequacy or inadequacy of an action (e.g., a motor response, decision, judgment, etc.).
- FIDELITY - see physical fidelity, task fidelity, realism, psychological realism.
- GENERALIZATION - the use of previously learned cue or response discriminations, and their processing, in a new or differing context.
- GUIDANCE - directing a person (usually a learner) to perceive, think, or act in a particular manner; the focus is usually on cues to be discriminated, ways of interpreting them, or specific responses to make.
- IOS - instructor/operator station for an ATD.

ISD - instructional systems development: procedural approaches to the analysis of training requirements and development of training systems.

INTERFERENCE - (1) the confusion or competition of one cue or response with another, usually similar, cue or response; (2) the disruption of cue and response discriminations due to extraneous events that compete for the performer's attention.

INTRINSIC FEEDBACK - feedback that is inherent in, or arises naturally from, the performance of an action; refers especially to realistic effects of operational task performance whether in an aircraft or a simulator.

KINESTHETIC FEEDBACK - feedback that is part of the "feel" of ongoing movements, such as control inputs, that is used to guide and monitor the action.

KINESTHETIC MEDIATION - the interpretation of movement cues and the monitoring of physical actions through the "feel" of the actions.

MASTERY - the ability to perform at a high level of proficiency; generally, elements of performance will have become more or less mechanical with various superfluous cognitive aids reduced to a minimum.

MEDIATION - (1) the use of past experience to provide cue meaning to stimuli, process information contained in cues, and select and implement a response or action; (2) an approach to explaining or predicting transfer of ATD-trained skills to aircraft performance that is based on (1).

MOTIVATION - the degree of intent to learn or perform in a superior manner as evidenced by conscientious involvement in learning or performance.

OFT - operational flight trainer.

OVERLEARNING - superior mastery that is presumed to occur when practice of a skill continues substantially beyond the point when proficiency was first achieved.

PHYSICAL FIDELITY - the degree of structural or dynamic correspondence of an ATD to a given aircraft.

PRACTICE - deliberate participation in activities for the purpose of learning or mastering skills that depend on the thoughts and motor actions involved in the activities.

PSYCHOLOGICAL REALISM - the same as Realism, except that this term denotes the role of subjective or mediational foundations for realism, regardless of the degree of objective equivalence of ATD and aircraft experiences.

REALISM - the extent to which an aircrewman's experiences in an ATD correspond to experiences as they would actually occur in an aircraft under a given set of conditions.

RESPONSE - any motor, perceptual, or mental act by a person; as used here, response generally refers to an element of an overall action as opposed to the overall action itself.

RETENTION - the capacity to remember task requirements, and perform accordingly, after a lapse of time during which the task was not practiced.

STRES - Simulator Training Requirements and Effectiveness Study.

SELF-GUIDANCE - guidance that a person has learned to provide himself, usually through understanding of the interrelations of elements of task performance and its relation to and effects on the system (e.g., aircraft) involved.

SIMILARITY - (1) the degree of physical fidelity or correspondence of stimuli in an ATD, or task actions in an ATD, to their counterparts in a target aircraft; (2) an approach to explaining and predicting transfer of ATD-trained skills to aircraft performance that is based on (1).

STIMULUS - an external or internal event capable of affecting a sense receptor and of acquiring cue value (meaning).

SUPPLEMENTAL FEEDBACK - feedback provided, usually during training, that is not of itself inherent in naturally occurring outcomes of actions.

TASK FIDELITY - the degree of correspondence of cues and responses accompanying task performance in an ATD to those characteristic of analogous performance in a given aircraft.

TASK INTEGRATION - the process of combining elements of task performance into an effective pattern such that cue interpretations and actions involved are sufficient for proficient operational performance.

TRAINING EFFECTIVENESS - the thoroughness with which the objectives of training have been achieved, regardless of training efficiency.

TRAINING EFFICIENCY - the extent to which training resources (including time) are used economically while achieving training effectiveness.

TRANSFER - the use of skills learned in one context (e.g., an ATD) in a substantially different context (e.g., an aircraft).

TRANSITION TRAINING - training for aircrewmembers transitioning to different operational aircraft.

UPT - undergraduate pilot training: initial pilot qualification training.

VERBAL MEDIATION - mediation that depends heavily on conscious or unconscious use of language and related systems of symbolic processing.

WST - weapon systems trainer.

